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Engineering Design File

PROJECT NO. 23052

VES-SFE-20 Hot Waste Tank Retrieval and Demolition Structural Design

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

INEEL
Idaho National Engineering and Environmental Laboratory

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ENGINEERING DESIGN FILE

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1. Title: VES-SFE-20 Hot Waste Tank Retrieval and Demolition Structural Design Page 1 of 2

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   Building/Type NA SSC ID VES-SFE-20 Site Area INTEC

3. NPH Performance Category: ________ or ☒ N/A

4. EDF Safety Category: ________ or ☒ N/A SCC Safety Category: C.G. or ☐ N/A

5. Summary:
This Engineering Design File document was prepared for the SFE-20 Hot Waste Tank remediation design project. The purpose is to document the structural design and analysis preformed in support of the remediation work to retrieve and dispose of the underground hot waste storage tank. This Engineering Design File contains the calculations and sketches for the design and the vault roof removal and demolition, tank removal analysis, and rigging design and the design of a precast concrete replacement roof to be placed back on the vault once the tank has been removed.

6. Review (R) and Approval (A) and Acceptance (Ac) Signatures:
(See instructions for definitions of terms and significance of signatures.)

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ENGINEERING DESIGN FILE

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PROFESSIONAL ENGINEER
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6-19.03
STATE OF IDAHO
PATRICK WAYNE BRAGASSA

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VES-SFE-20 Hot Waste Tank Retrieval and Demolition Structural Design

1. PURPOSE

The Vessel-Storage Fuel Exterior (VES-SFE)-20 Hot Waste Storage Tank will be removed and disposed of as part of the Waste Area Group 3 (WAG 3) cleanup plan. This project will remove the tank and its contents; the vault; the remainder of the SFE-20 structures, piping, and other components; and any potentially contaminated soils and transport them for either on-Site or off-Site disposal. Excavation and removal of the VES-SFE-20 Tank System, plus any contaminated underlying soils, are complicated in that active structures and utilities exist near the excavation site. In addition, the tank is located approximately 10 ft below grade with the vault floor extending deeper. An active concrete pipe corridor supporting operation of VES-SFE-106 was constructed over a portion of the VES-SFE-20 vault and doweled into the foundation of CPP-642, further complicating removal. As a result, the approach for the removal of the VES-SFE-20 Tank System will consist of two phases.

Phase I will consist of removing the tank and piping from within the tank vault by excavating down to and exposing the concrete vault roof. The vault roof will be removed as well as the tank and associated piping. A replacement precast concrete roof will be placed over the vault and the area backfilled. The site will be returned to a safe condition until the commencement of Phase II.

Phase II activities will consist of removing the concrete structures, including the vault, tunnel, and pump pit, as well as the remaining piping, Building CPP-642 structure, and any contaminated adjacent and underlying soils. Phase II activities will occur following the closure or deactivation of VES-SFE-106 and CPP-648.

2. SCOPE

The scope of this analysis and design includes the calculations, sketches, drawings, and diagrams required to support the structural design of the remediation work. Specifically, this will include the design of the existing vault concrete roof removal process, a replacement roof design, and the design and analysis of the tank removal method.

3. CONCLUSIONS/RESULTS

See Appendix A for detailed drawings of the final design.

4. SAFETY CATEGORY

The VES-SFE-20 remediation work has been considered a "Consumer Grade" project and all design and construction will comply with the quality requirements specified for this level of safety category.

5. NATURAL PHENOMENA HAZARDS PERFORMANCE CATEGORY

Natural phenomena hazards loads do not apply to this project and will not be considered.

6. STRUCTURE SYSTEM OR COMPONENT DESCRIPTION

The SFE-20 Hot Waste Tank System is also known as Site CPP-69, which consists of a concrete vault containing an abandoned radioactive, liquid-waste storage tank. The top of the tank vault is located about 3 m (10 ft) below grade. The tank system consists of the tank contents, tank, and associated structures located east of Building CPP-603. The VES-SFE-20 system includes the VES-SFE-20 tank, tank vault, access tunnel, associated pump pit, and Building CPP-642 with related piping and instrumentation.

7. MATERIALS

INEEL Drawing No. 105972 identifies the concrete to have a compressive strength of 3,000 psi and the reinforcing steel to have a minimum yield stress of 20,000 psi.

8. DESIGN LOADS

The items that are to be removed shall be analyzed using their calculated dead weight. The SFE-20 tank load shall include the interior piping plus 371 lb of sludge, which may be present. Rigging will be designed assuming a maximum of two lift points will carry the lifted load. The vault replacement roof shall be designed to carry the soil weight above the vault.

9. ASSUMPTIONS

The vault roof slab should be removed in one piece, if possible to minimize exposure. The vault concrete is in good condition as observed in existing photographs and video inspections.

Access to the bottom of the tank is very restricted and no lifting fixtures are currently attached to the tank requiring rigging to be attached to the top of the tank. The vault roof opening will be smaller than the tank, requiring the tank to be lifted out at an angle. Assume two cranes will be used to safely perform this lift. It is assumed that the tank has no significant corrosion and is good condition.

10. ACCEPTANCE CRITERIA

Vault Roof Removal: The roof slab was analyzed for structural integrity during lifting to the requirements of ACI-318, American Concrete Institute, "Building Code Requirements for Structural Concrete." Load carrying items were analyzed and designed with a factor of safety of 3:1 on yield strength as required by DOE-STD-1090, "Hoisting and Rigging Standard," and ASME B30.20, "Below the Hook Lifting Devices." The support beams that will be used to lift the roof slab are each designed to support the entire weight of the slab.

Vault Roof: The new vault roof design shall be in conformance to the requirements of ACI-318, American Concrete Institute, "Building Code Requirements for Structural Concrete."

Tank Lift Design: Load carrying items were analyzed and designed with a factor of safety of 3:1 on yield strength as required by DOE-STD-1090, "Hoisting and Rigging Standard," and ASME B30.20, "Below the Hook Lifting Devices."

11. REFERENCES

ACI-318/99, "Building Code Requirements for Structural Concrete," American Concrete Institute, 1999.

ASME B30.20, "Below the Hook Lifting Devices," American Society for Mechanical Engineers.

DOE-STD-1090, 2001, "Hoisting and Rigging Standard," U.S. Department of Energy, April 2001.

Appendix A

Calculations

Vault Roof Removal and Rigging

Vault Replacement Roof Design

Tank Removal Design

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STF-20 Tank Removal	10/02	P. Bragassa

Vault Roof:

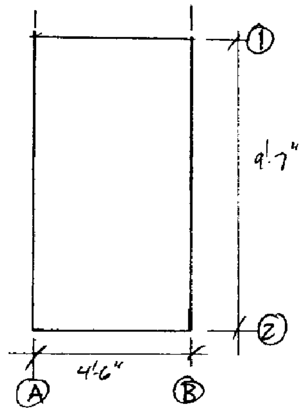
Determine IF Roof can be Removed in one piece

size will be 9'-7" x 4'-6" x 8"

wt = 9.58' x 4.5 x .67 x 150 = 4333 #

- Determine if slab is strong enough to be supported / Lifted in this manner.

1) First saw cuts will be at (A) & (B). Therefore worst case, slab will span 9'-7", until beams are added



$f'_c = 3000\,psi$

$f_s = 20{,}000\,psi$

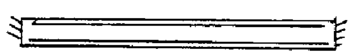
$W_d = 150\,(.67) = 100\,psf$

$W_u = 100\,psf\,(1.4) = 140\,psf$

$= 140\,(4.8) = 672\,plf$

Analyze as a 4'-6" x 8" Beam

$M_u = 672 \frac{(9.58)^2}{8} = 7.71^{K\text{-}ft}$ (bottom) $= 92.5^{K\text{-}in}$



Top Steel:
#4 @ 12
≈ 4 bars Ast = .80

Bottom:
#4 @ 18"
≈ 3 bars
Ast = .60

d top bending = 8" - 2" - .25 = 5.75"

d bottom bending = 8" - .75 - .25 = 7"

$M_{top} = 672\,(9.58)^2/12 = 61.67^{K\text{-}in}$

$a_{Top} = \frac{A_s f_y}{.85 f'_c b} = \frac{.80\,(20{,}000)}{.85\,(3000)(54)} = .1162''$

$\phi M_{n_{top}} = (.9) A_s f_y \left(d - \frac{a}{2}\right) = (.9)(.80)(20)\left(5.75 - \frac{.1162}{2}\right) = \boxed{81.96\ K\text{-}in} > 61.67$ OK

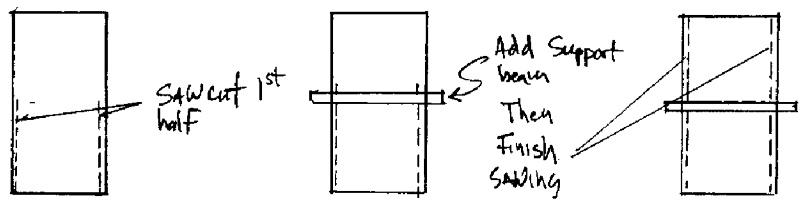
$a_{bottom} = \frac{.60\,(20{,}000)}{.85\,(3000)(54)} = .0871$ $\phi M_n = (20).9\,(.60)\left(7 - \frac{.0871}{2}\right) = \boxed{75.13\ K\text{-}in}$

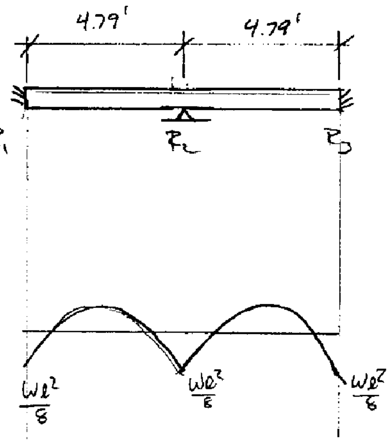
$M_u = 92.5^{K\text{-}in} > \phi M_n = 75.13$ ∴ N.G.

Will need to add temporary support or cut in Sections

SFE-20 TANK Removal	10/02	P. Bragassa

Vault Roof: For exposure & contamination control, it is advantageous to remove in one section. Therefore, a temporary support will be added in the center, after ½ the cuts have been made.





$M_{top} = \frac{wl^2}{8} = 672\ \frac{(4.79)^2}{8} = 23.12^{K\text{-}in}$ ✓OK

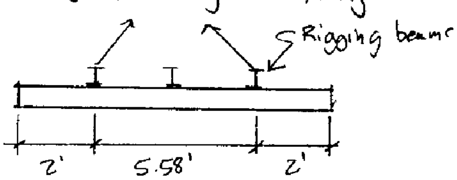
$M_{bott} = \frac{9}{128}(wl^2) = \frac{9}{128}(672)(4.79)^2$
$= 13.1K\text{-}in$ ✓OK

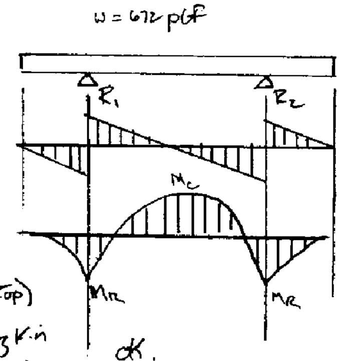
$R_1 = R_3 = \frac{3}{8}wl = \frac{3}{8}(672)(4.79)$
$= 1208^{\#}$

$R_2 = 1.25\,(672)(4.79) = 4{,}023^{\#}$

∴ USE W6×20 (From earlier trial run, verify with Rigging design)

Check Slab during Lifting:





$R_1 = R_2 = \frac{672(9.58)}{2} = 3219^{\#}$

$V = 672(2) = 1344^{\#}$ or $\frac{672}{2}(9.58 - 2(2)) = 1874^{\#}$

$M_R = \frac{wa^2}{2} = \frac{672(2)^2}{2} = 1344^{\#\text{-}ft} = 16.13^{K\text{-}in}$ (Top)

$M_c = \frac{wl}{8}(l - 4a)\ \frac{672(9.58)}{8}(9.58 - 4(2)) = 15.3^{K\text{-}in}$ (Bottom)

ok.

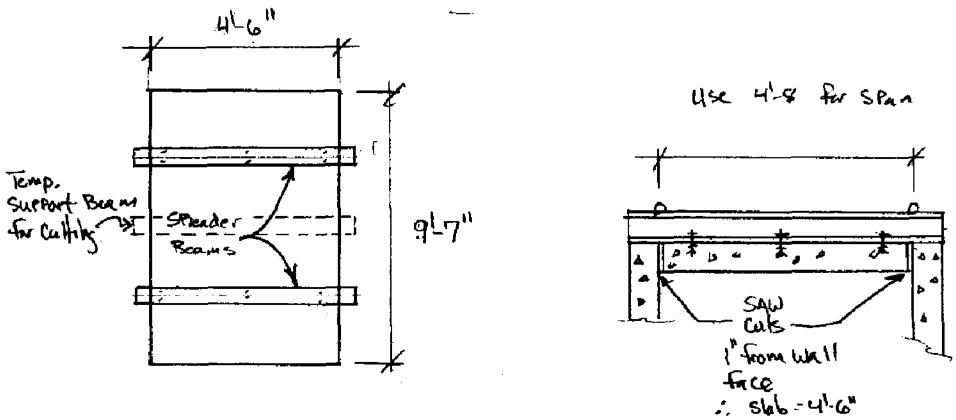
SFE-20 Tank Removal	10/02	P. Bragassa	8/

Vault Roof Removal:

SUPPORT Beams: USE Temporary beams to Support Roof During Saw cutting and for use as Rigging Spreader beams.

Max Roof Piece: 9'-3" x 4'-6" x 8"

∴ Wt = 9.25' x 4.5' x .667' x 150 pcf = 4162# SAY 4400#
For any MISC unknowns (Steel deck, etc)



Assumptions:

1) Concrete is in good condition, with little deterioration, cracks. Drawing 105972 indicates that concrete was water proofed. VIDEO ON Tank inspection does show significant damage. Will verify during sampling entry.

2) Hilti bolts will be used to secure beams to concrete. Additional bolts will be used than necessary to allow for unforseen cracks, deterioration or unknown conditions. This will help secure concrete even if cracks or failure occurs.

3) Vault Data: INEEL Drawing: 105972 — f'_c = 3000 psi
Year constructed: 1957 — F_y = 20,000 psi

4) TWO Spreader/Support Beams will be used, each designed for total load. A Temporary beam is required during cutting.

SFE-20 Tank Removal	10/02	P. Bragassa

Spreader/Support Beam Design:

Free span = 4'-8"

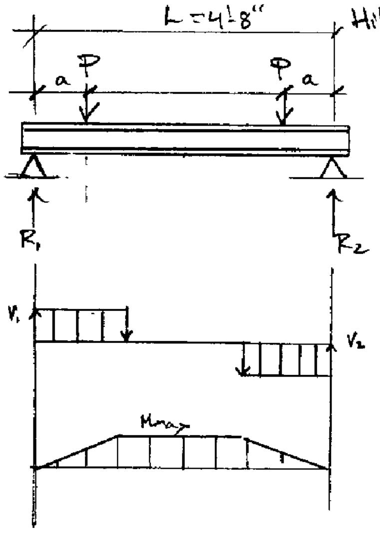
Loads: If (3) pairs of Hilti bolts are used to secure the slab to each beam, then:

$$\frac{4400^{\#}\text{ total slab wt}}{3\text{ pairs}} = 1467^{\#}\text{ per pair of bolts}$$

or

$$\frac{4400^{\#}}{2\text{ pair}} = 2200^{\#}/\text{pair of bolts}$$ ← use for design

Which results in each pair of bolts capable of supporting ½ total load. This can be easily achieved with Hilti-Bolts.



P = 2200# (Slab wt only)

$R_1 = R_2 = P = 2200^{\#}$

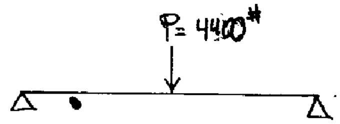
Max shear: $V_1 = +P = 2200^{\#}$
$V_2 = -P = 2200^{\#}$

Max Moment = $M_{max} = Pa$

let a = 1 ft $= 2200(1)$

$= 2200$ #-ft

$= 26,400$ #-in



OR if single point load @ center: (for beam design)

$$M = \frac{Pl}{4} = \frac{4400(4.67)}{4} = 5,137\text{ \#-ft}$$
$$= 61,644\text{ \#-in}$$

$$V = \frac{P}{2} = 2200^{\#}$$

SFE-20 TANK Removal	10/02	P. Bragassa

SPREADER/SUPPORT Beam Design:

- Design For Slab wt only

$M_{max} = 61,644$ #-in (Worst case) using Gr 50 Steel and $F_b = .6(50) = 30$ ksi

$S_{req} = \frac{61,644 \text{ \#-in}}{30,000 \text{ psi}} = 2.05 \text{ in}^3$

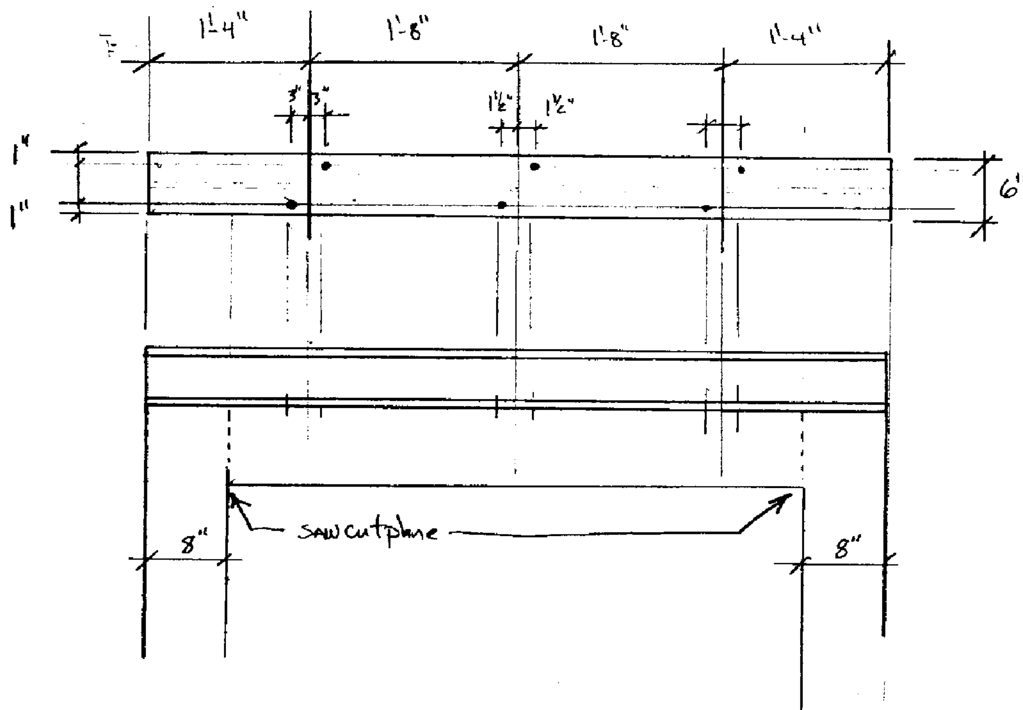
Use a W6X20 Gr 50 beam

$S_x = 13.4 \text{ in}^3$ ✓OK.

$A = 5.87 \text{ in}^2$

$I_x = 41.4 \text{ in}^4$

Anchor Layout: Based on Concrete Cone Failure spacing.



A single W6X20 Beam can support the entire slab.

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Anchor Design:

$f'_c = 3000$ psi;
Using 4 Hilti Kwik Bolt II, C.S. ½" ϕ embedded 2¼"

Allowable load per bolt = 1310#/Bolt = 2620#/Pair

3 Pairs will be used to assure proper support of concrete since condition is unknown. Design also assumes 1 beam supports the whole wt.

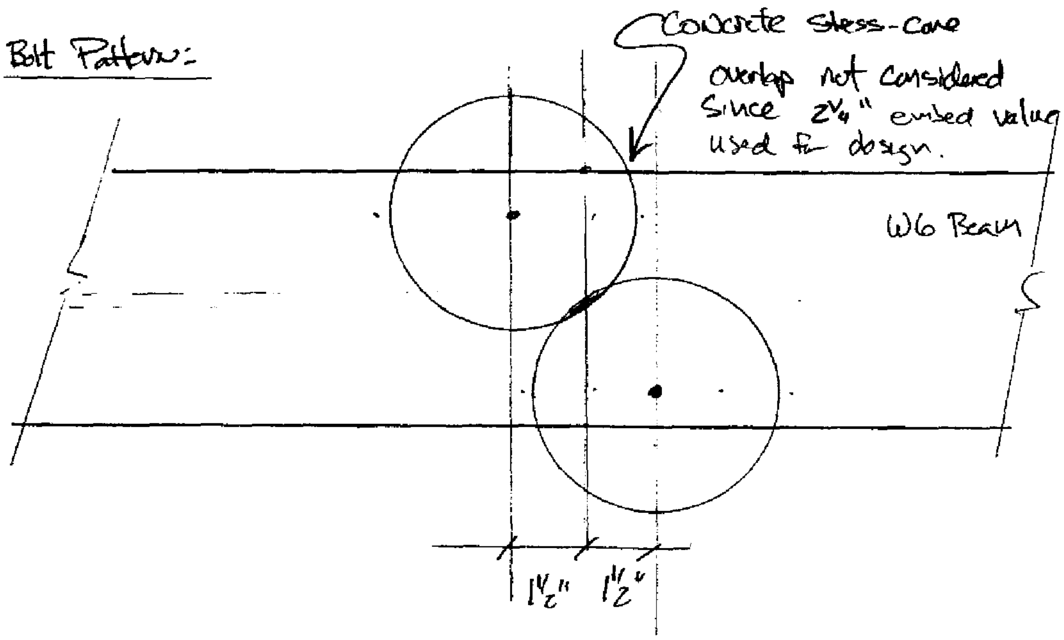
$$\frac{4400}{3} = 1467\#/\text{Pair}$$

$$\frac{4400}{2} = 2200\#/\text{Pair}$$

< 2620# ✓OK

USE Kwik Bolt II ½" ϕ embed 3" to assure good concrete, Inspect holes prior to setting bolts.

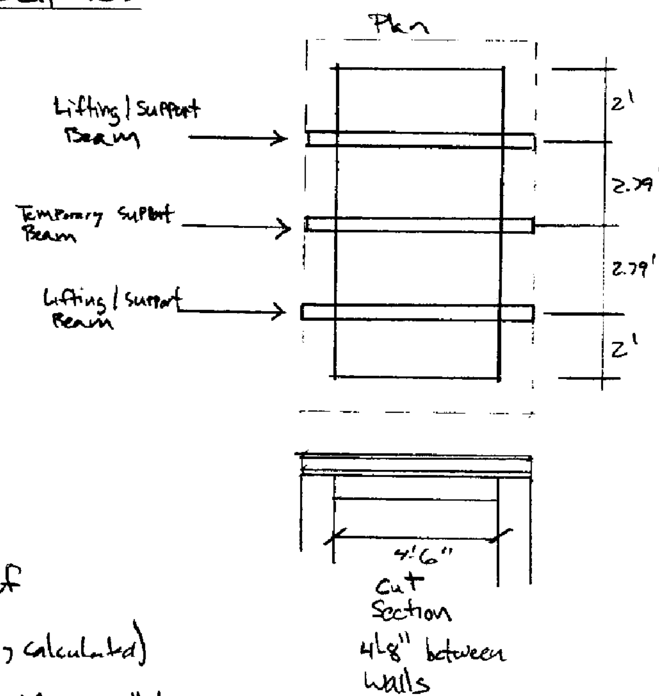
Bolt Pattern:



SFE-20 Tank Removal | 10/02 | P. Bragassa

Support Beams / Lifting Beams:

- Design Temp Beam
- Design Lifting Beams



Temp. Support Beam:

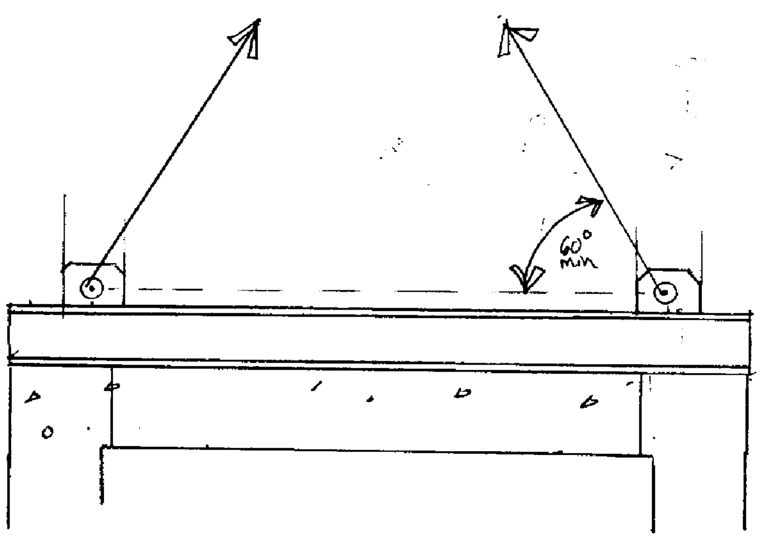
TRIB. AREA = 5'-7"

Slab wt = 100 psf (5.58') = 558 plf

Total slab wt = 4400 # (Previously calculated)

Based on 9'-7" x 4'-6" x 8" and γ = 150 #/cF

Each Beam designed for total load.

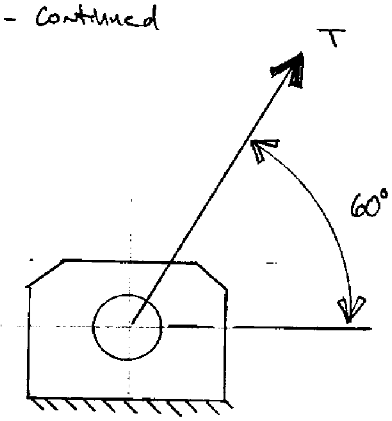


SFE-20 TANK Removal	10/02	P. BRAGASSA

LIFTING BEAMS - Continued

Lift Brackets:

USING
F.S = 1/3 Yield
Per DOE STD-1090
Hoisting & Rigging
STD.



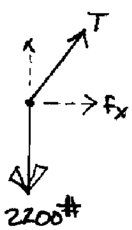
Weld:
Use 1/4" fillet
on both sides.

L = 6"

$P = (.707)(70)(.3)(1/4)$
$= 3.71^K/in$
$= 22.27^K$ ✓ oK

Assuming each beam carries total load = 4400#
∴ EACH Bracket will be designed for 1/2 total load.

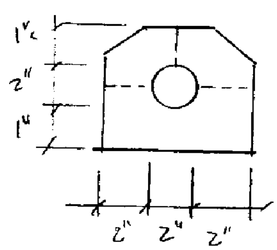
$T = \dfrac{2200^{\#}}{\sin 60} = 2541^{\#}$



Horizontal shear:
$F_x = T\cos 60 = 2541^{\#}\cos 60$
$= 1271^{\#}$

Check: $\sqrt{1271^2 + 2200^2} = 2540.34^{\#}$ ✓ oK

Using 1/2" A36 Plate:



Tensile failure: (AISC-J.4)

$A = 2" + 2" = 4"\,(1/2) = 2\,in^2$

For A36 $F_t = 0.50\,F_u$
$= .5(58) = 29\,Ksi$

or $\dfrac{F_y}{3} = \dfrac{36}{3} = 12\,Ksi$

$P = 12\,Ksi\,(2\,in^2) = 24\,Kips$ allowed oK

Shear Rupture: $F_v = .30\,F_u$
$= .30\,(58) = 17.4\,Ksi$
$F = 17.4(1.5(.5)) = 13.1^K$
or $12\,Ksi\,(1.5(.5)) = 9^K$ ✓ oK

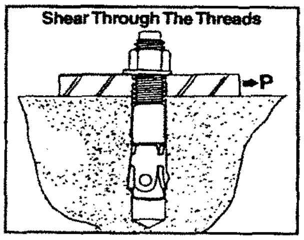
Kwik Bolt II Expansion Anchor 4.3.3

Carbon Steel Kwik Bolt II Allowable Loads in Concrete

Anchor Diameter in. (mm)	Embedment Depth in. (mm)	2000 psi (13.8 MPa)		3000 psi (20.7 MPa)		4000 psi (27.6 MPa)		6000 psi (41.4 MPa)	
		Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
1/4 (6.4)	1 1/8 (29)	270 (1.2)	430 (1.9)	330 (1.5)	430 (1.9)	380 (1.7)	430 (1.9)	470 (2.1)	430 (1.9)
	2* (51)	560 (2.5)	530 (2.4)	590 (2.6)	530 (2.4)	630 (2.8)	530 (2.4)	670 (3.0)	530 (2.4)
	3 3/4* (95)	670 (3.0)		670 (3.0)		670 (3.0)			
3/8 (9.5)	1 5/8 (41)	530 (2.4)	990 (4.4)	650 (2.9)	1040 (4.6)	750 (3.3)	1100 (4.9)	850 (3.8)	1100 (4.9)
	2 1/2* (64)	1200 (5.3)	1470 (6.5)	1290 (5.7)	1470 (6.5)	1370 (6.1)	1470 (6.5)	1550 (6.9)	1470 (6.5)
	4 1/4* (108)	1330 (5.9)		1390 (6.2)		1440 (6.4)			
1/2 (12.7)	2 1/4 (57)	1170 (5.2)	1940 (8.6)	1310 (5.8)	1970 (8.8)	1450 (6.4)	1970 (8.8)	1730 (7.7)	1970 (8.8)
	3 1/2* (89)	1870 (8.3)	2450 (10.9)	2130 (9.5)	2450 (10.9)	2400 (10.7)	2450 (10.9)	2800 (12.5)	2450 (10.9)
	6* (152)	2080 (9.3)		2310 (10.3)		2530 (11.3)			
5/8 (15.9)	2 3/4 (70)	1600 (7.1)	3070 (13.7)	1870 (8.3)	3070 (13.7)	2130 (9.5)	3070 (13.7)	2670 (11.9)	3070 (13.7)
	4** (102)	2400 (10.7)	3840 (17.1)	2850 (12.7)	3840 (17.1)	3290 (14.6)	3840 (17.1)	4190 (18.6)	3840 (17.1)
	7** (178)	3200 (14.2)		3470 (15.4)		3730 (16.6)			
3/4 (19.1)	3 1/4 (83)	1970 (8.8)	4140 (18.4)	2320 (10.3)	4140 (18.4)	2670 (11.9)	4140 (18.4)	3200 (14.2)	4140 (18.4)
	4 3/4** (121)	2930 (13.0)	5120 (22.8)	4130 (18.4)	5120 (22.8)	4800 (21.4)	5120 (22.8)	5870 (26.1)	5120 (22.8)
	8** (203)	4000 (17.8)		4930 (21.9)		5870 (26.1)		6320 (28.1)	
1 (25.4)	4 1/2 (114)	3330 (14.8)	7070 (31.4)	4050 (18.0)	7600 (33.8)	4670 (20.8)	8140 (36.2)	5070 (22.6)	9200 (40.9)
	6 (152)	4930 (21.9)	9200 (40.9)	6000 (26.7)	9200 (40.9)	7070 (31.4)	9200 (40.9)	8400 (37.4)	
	9 (229)	6670 (29.7)		7670 (34.1)		8670 (38.6)		10670 (47.5)	

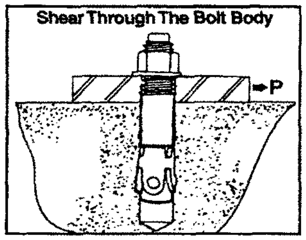
* Values shown are for a shear plane acting through the anchor bolt body. When the shear plane is acting through the anchor bolt threads, reduce the shear values by 20%.

Shear Through The Threads



** Values shown are for a shear plane acting through the anchor bolt body. When the shear plane is acting through the anchor bolt threads, reduce the shear value by 12%.

Shear Through The Bolt Body



All other values shown are for shear plane acting through either body or threads.

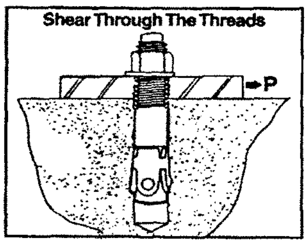
HILTI **Anchoring Systems**

4.3.3 Kwik Bolt II Expansion Anchor

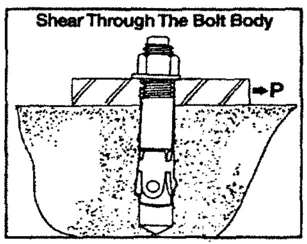
Carbon Steel Kwik Bolt II Ultimate Loads in Concrete

Anchor Diameter in. (mm)	Embedment Depth in. (mm)	2000 psi (13.8 MPa)		3000 psi (20.7 MPa)		4000 psi (27.6 MPa)		6000 psi (41.4 MPa)	
		Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)	Tension lb (kN)	Shear lb (kN)
1/4 (6.4)	1 1/8 (29)	1000 (4.4)	1600 (7.1)	1230 (5.5)	1600 (7.1)	1430 (6.4)	1600 (7.1)	1750 (7.8)	1600 (7.1)
	2* (51)	2100 (9.3)	2000 (8.9)	2225 (9.9)	2000 (8.9)	2350 (10.5)	2000 (8.9)	2500 (11.1)	2000 (8.9)
	3 3/4* (95)	2500 (11.1)		2500 (11.1)		2500 (11.1)			
3/8 (9.5)	1 5/8 (41)	2000 (8.9)	3700 (16.5)	2450 (10.9)	3900 (17.3)	2825 (12.6)	3900 (17.3)	3200 (14.2)	3900 (17.3)
	2 1/2* (64)	4500 (20.0)	5500 (24.5)	4825 (21.5)	5500 (24.5)	5150 (22.9)	5500 (24.5)	5800 (25.8)	5500 (24.5)
	4 1/4* (108)	5000 (22.2)		5200 (23.1)		5400 (24.0)			
1/2 (12.7)	2 1/4 (57)	4400 (19.6)	7250 (32.2)	4925 (21.9)	7360 (32.7)	5450 (24.2)	7360 (32.7)	6500 (28.9)	7360 (32.7)
	3 1/2* (89)	7000 (31.1)	9200 (40.9)	8000 (35.6)	9200 (40.9)	9000 (40.0)	9200 (40.9)	10500 (46.7)	9200 (40.9)
	6* (152)	7800 (34.7)		8650 (38.5)		9500 (402.3)			
5/8 (15.9)	2 3/4 (70)	6000 (26.7)	11500 (51.2)	7000 (31.1)	11500 (51.2)	8000 (35.6)	11500 (51.2)	10000 (44.5)	11500 (51.2)
	4** (102)	9000 (40.0)	14200 (63.2)	10670 (47.5)	14200 (63.2)	12350 (54.9)	14200 (63.2)	15700 (69.8)	14200 (63.2)
	7** (178)	12000 (53.4)		13000 (57.8)		14000 (62.3)			
3/4 (19.1)	3 1/4 (83)	7400 (32.9)	15500 (68.9)	8700 (38.7)	15500 (68.9)	10000 (44.5)	15500 (68.9)	12000 (53.4)	15500 (68.9)
	4 3/4** (121)	11000 (48.9)	19200 (85.4)	15500 (68.9)	19200 (85.4)	18000 (80.1)	19200 (85.4)	22000 (97.9)	19200 (85.4)
	8** (203)	15000 (66.7)		18500 (82.3)		22000 (97.9)		23700 (105.4)	
1 (25.4)	4 1/2 (114)	12500 (55.6)	26500 (117.9)	15200 (67.6)	28500 (126.8)	17500 (77.8)	30500 (135.7)	19000 (84.5)	34500 (153.5)
	6 (152)	18500 (82.3)	34500 (153.5)	22500 (100.1)	34500 (153.5)	26500 (117.9)	34500 (153.5)	31500 (140.1)	
	9 (229)	25000 (111.2)		28750 (127.9)		32500 (144.6)		40000 (177.9)	

* Values shown are for a shear plane acting through the anchor bolt body. When the shear plane is acting through the anchor bolt threads, reduce the shear values by 20%.



** Values shown are for a shear plane acting through the anchor bolt body. When the shear plane is acting through the anchor bolt threads, reduce the shear value by 12%.



All other values shown are for shear plane acting through either body or threads.

4.3.3.3 TECHNICAL DATA

Kwik Bolt II Specification Table

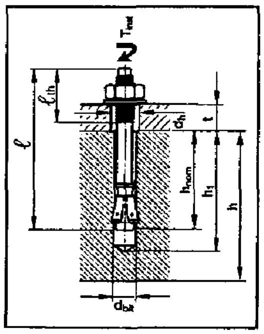
Details \ Bolt Size	in. (mm)	1/4 (6.4)		3/8 (9.5)		1/2 (12.7)		5/8 (15.9)		3/4 (19.1)		1 (25.4)	
d_{bit}: nominal bit diameter[1]	in.	1/4		3/8		1/2		5/8		3/4		1	
h_{min} / h_{nom}: minimum/standard depth of embedment	in. (mm)	1 1/8 (29)	2 (51)	1 5/8 (41)	2 1/2 (64)	2 1/4 (57)	3 1/2 (89)	2 3/4 (70)	4 (102)	3 1/4 (83)	4 3/4 (121)	4 1/2 (114)	6 (152)
h_1: minimum/standard hole depth	in. (mm)	1 3/8 (35)	2 1/4 (57)	2 (51)	2 7/8 (73)	2 3/4 (70)	4 (102)	3 3/8 (86)	4 5/8 (118)	4 (102)	5 1/2 (140)	5 1/2 (140)	7 (178)
ℓ: anchor length min./max. other length available	in. (mm)	1 3/4 (44)	4 1/2 (114)	2 1/4 (57)	7 (178)	2 3/4 (70)	7 (178)	3 3/4 (95)	10 (254)	4 1/4 (108)	12 (305)	6 (152)	12 (305)
ℓ_{th}: thread length/ extra thread length	in. (mm)	3/4 (19)	3 (76)	7/8 / 1 1/8 (22/28)	4 (102)	1 1/4 (32)	4 (102)	1 1/2 (38)	3 1/2 / 4 1/2 (89/114)	1 1/2 (38)	3 1/2 / 4 1/2 (89/114)	2 1/4 (57)	4 1/2 (114)
d_h: wedge clearance hole in plate	in. (mm)	5/16 (7.9)		7/16 (11.1)		9/16 (14.3)		11/16 (17.5)		13/16 (20.6)		1 1/8 (28.6)	
T_{inst}: Recommended Installation Torque[2] Guide Values ft lb (Nm) — Normal weight Concrete, Stainless Steel	h_{min}	4 (5.4)		20 (27.0)		40 (54.1)		85 (115)		150 (203)		235 (318)	
Normal weight Concrete, Stainless Steel	h_{nom}	7 (9.5)		30 (40.5)		75 (101)		110 (149)		200 (270)		450 (608)	
Normal weight Concrete, Carbon Steel	h_{min}	4 (5.4)		20 (27.0)		40 (54.1)		85 (115)		150 (203)		250 (338)	
Normal weight Concrete, Carbon Steel	h_{nom}	7 (9.5)		25 (33.8)		65 (87.8)		110 (149)		235 (318)		450 (608)	
Lightweight Concrete, Carbon Steel	h_{min}	4 (5.4)		15 (20.3)		25 (33.8)		65 (87.8)		135 (182)		—	
Lightweight Concrete, Carbon Steel	h_{nom}	4 (5.4)		20 (27.0)		30 (40.5)		75 (101)		150 (203)		—	
Grout Filled Block, Carbon Steel	h_{min}	4 (5.4)		15 (20.3)		25 (33.8)		65 (87.8)		120 (162)		—	
Grout Filled Block, Carbon Steel	h_{nom}	4 (5.4)		20 (27.0)		30 (40.5)		75 (101)		130 (176)		—	
h: min. base material thickness		3" (76 mm) or 1.3 h_{ef}, whichever number is greater											

1. Hilti carbide-tipped drill bit or matched tolerance HILTI DD-B diamond core bits (available in diameters from 1/2" to 1").
2. Do not apply any type of lubricant to threads prior to torquing anchor.

Countersunk, Rod Coupling and HCKB Specification Table

Details \ Bolt Size	in. (mm)	1/4 Countersunk (6.4)		3/8 Countersunk (9.5)		3/8 Rod Coupling (9.5)	1/4 HCKB (6.4)
d_{bit}: nominal bit diameter	in.	1/4		3/8		3/8	1/4
h_{min} / h_{nom}: minimum/standard depth of embedment	in. (mm)	1 1/8 (29)	2 (51)	1 5/8 (41)	2 1/2 (64)	1 5/8 (41)	1 7/16 (37)
h_1: minimum/standard hole depth	in. (mm)	1 3/8 (35)	2 1/4 (57)	2 (51)	2 7/8 (73)	2 (51)	1 1/2 (38)
ℓ: anchor length min./max. other lengths available	in. (mm)	1 3/4 (44)	5 (127)	2 1/4 (57)	5 (127)	2 1/4 (127)	2 1/4 (127)
ℓ_{th}: thread length/ extra thread length	in. (mm)	3/4 (19.1)	3 (76)	7/8 / 1 1/8 (22/28)	4 (102)	7/8 (22)	N.A.
d_h: wedge clearance hole in plate	in. (mm)	5/16 (7.9)		7/16 (11.1)		7/16 (11.1)	5/16 (7.9)
T_{inst}: Recommended Installation Torque[1] Guide Values ft lb (Nm) — Normal weight Concrete, Stainless Steel	h_{min}	4 (5.4)		20 (27.0)		—	
Normal weight Concrete, Stainless Steel	h_{nom}	7 (9.5)		30 (40.5)		—	
Normal weight Concrete, Carbon Steel	h_{min}	4 (5.4)		20 (27.0)		20 (27.0)	
Normal weight Concrete, Carbon Steel	h_{nom}	7 (9.5)		25 (33.8)		—	
Lightweight Concrete, Carbon Steel	h_{min}	4 (5.4)		15 (20.3)		20 (27.0)	
Lightweight Concrete, Carbon Steel	h_{nom}	4 (5.4)		20 (27.0)		—	
Grout Filled Block, Carbon Steel	h_{min}	4 (5.4)		15 (20.3)		20 (27.0)	
Grout Filled Block, Carbon Steel	h_{nom}	4 (5.4)		20 (27.0)		—	
h: min. base material thickness		3" (76 mm) or 1.3 h_{ef}, whichever number is greater					

1. Do not apply any type of lubricant to threads prior to torquing anchor.

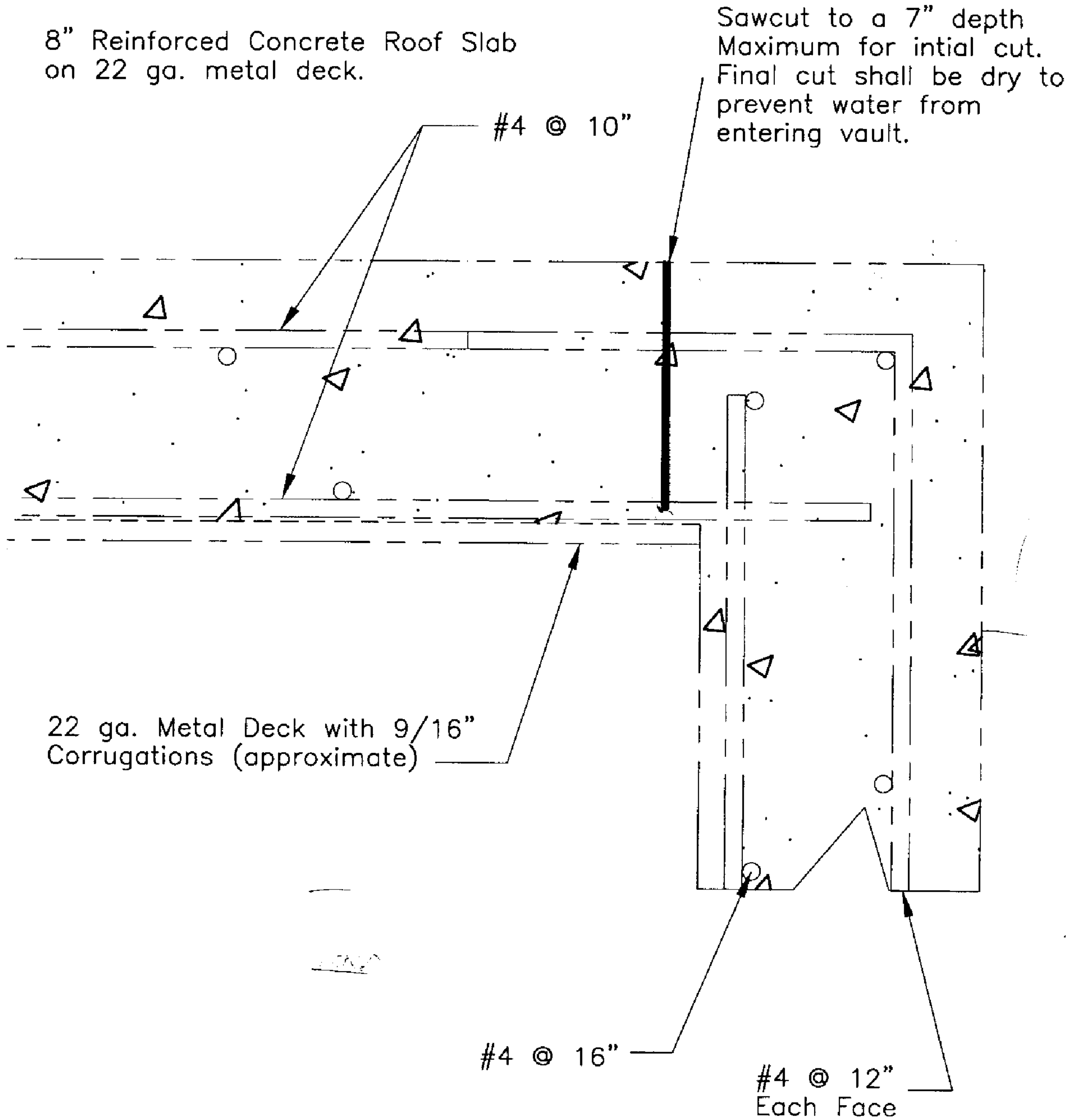


Combined Shear and Tension Loading

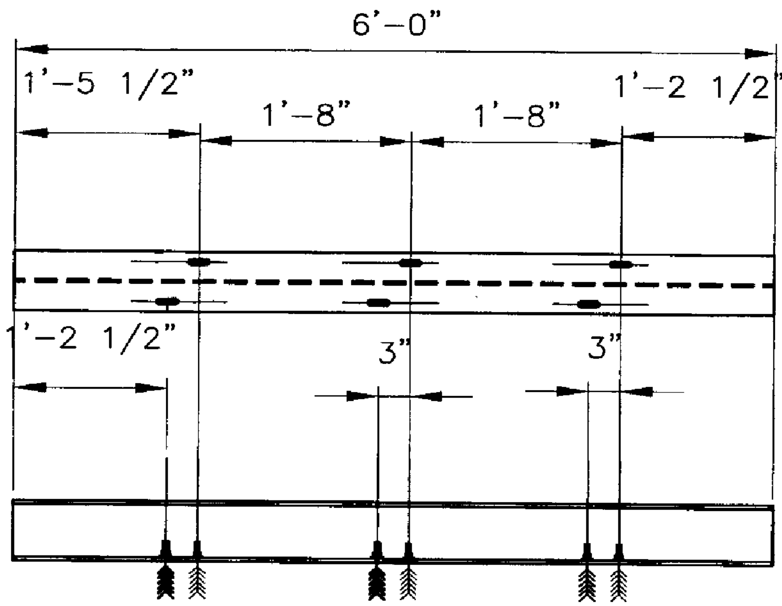
$$\left(\frac{N_d}{N_{rec}}\right)^{5/3} + \left(\frac{V_d}{V_{rec}}\right)^{5/3} \leq 1.0$$

(Ref. Section 4.1.3)

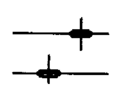
SFE-20 Tank Removal



SawCut Detail



W6x20 Support Beams



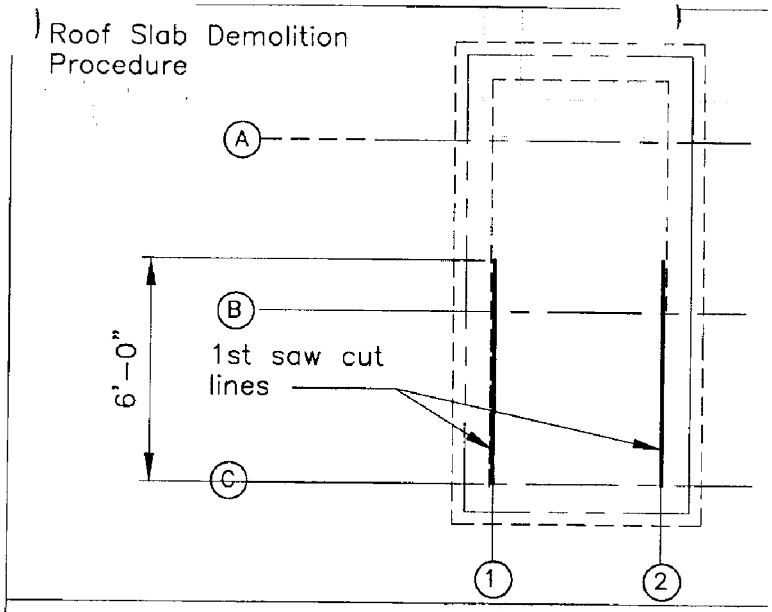
General Notes:

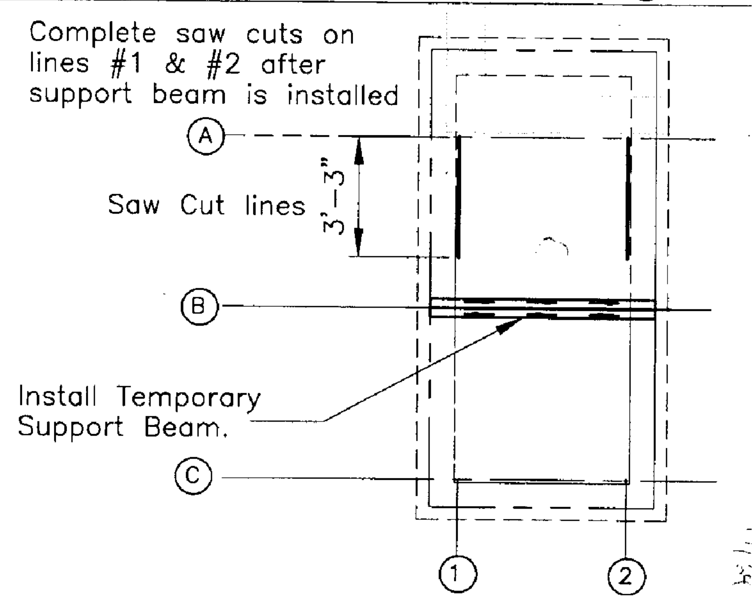
1. Temporary beams are required to support roof slab during demolition and removal. The first saw cuts shall be made on cut lines #1 & #2 starting at gridline "C" to a distance of 6'–0" to allow installation of the center support beam.

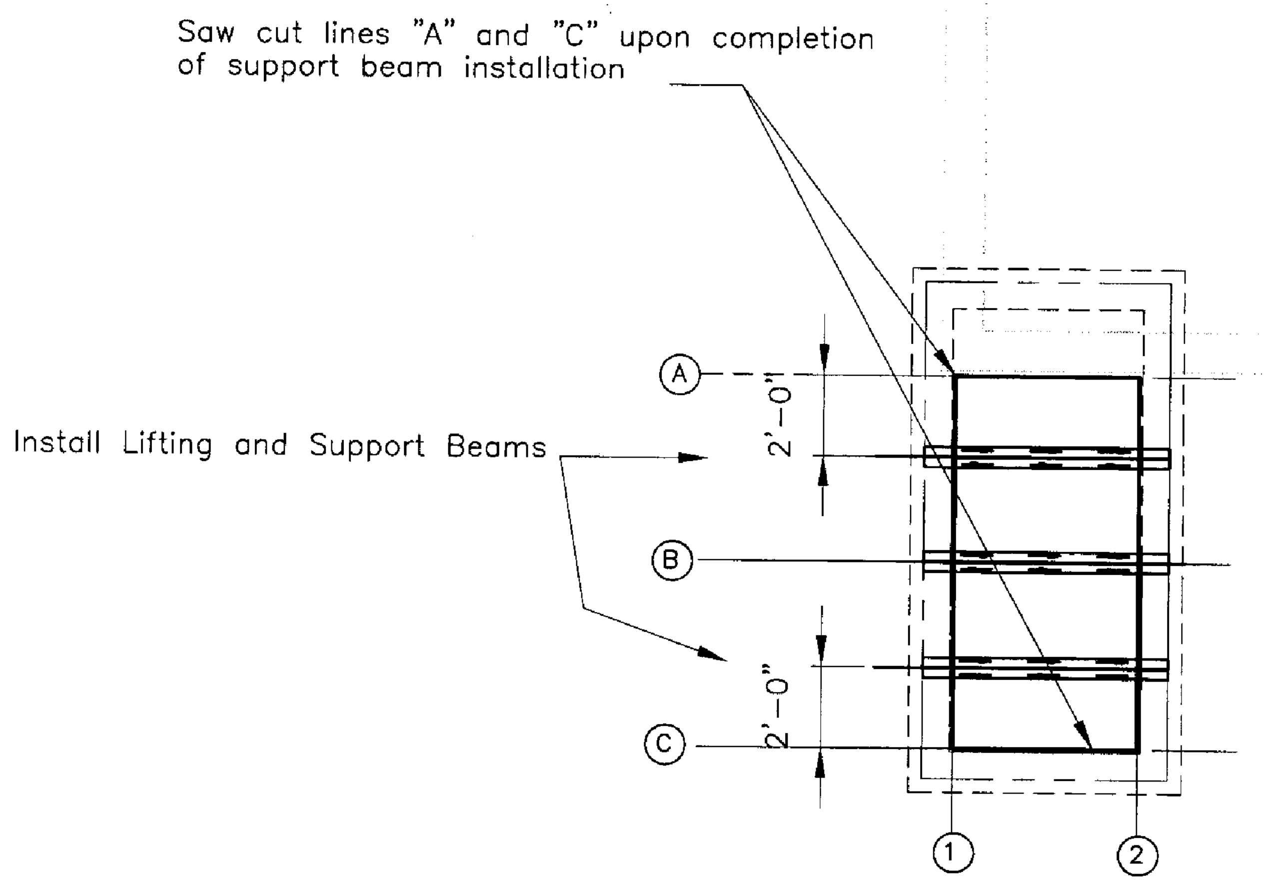
2. Install center support beam at grid line "B" and secure to slab. Once center support beam has been installed, cut lines #1 & #2 can be completed to grid line "A".

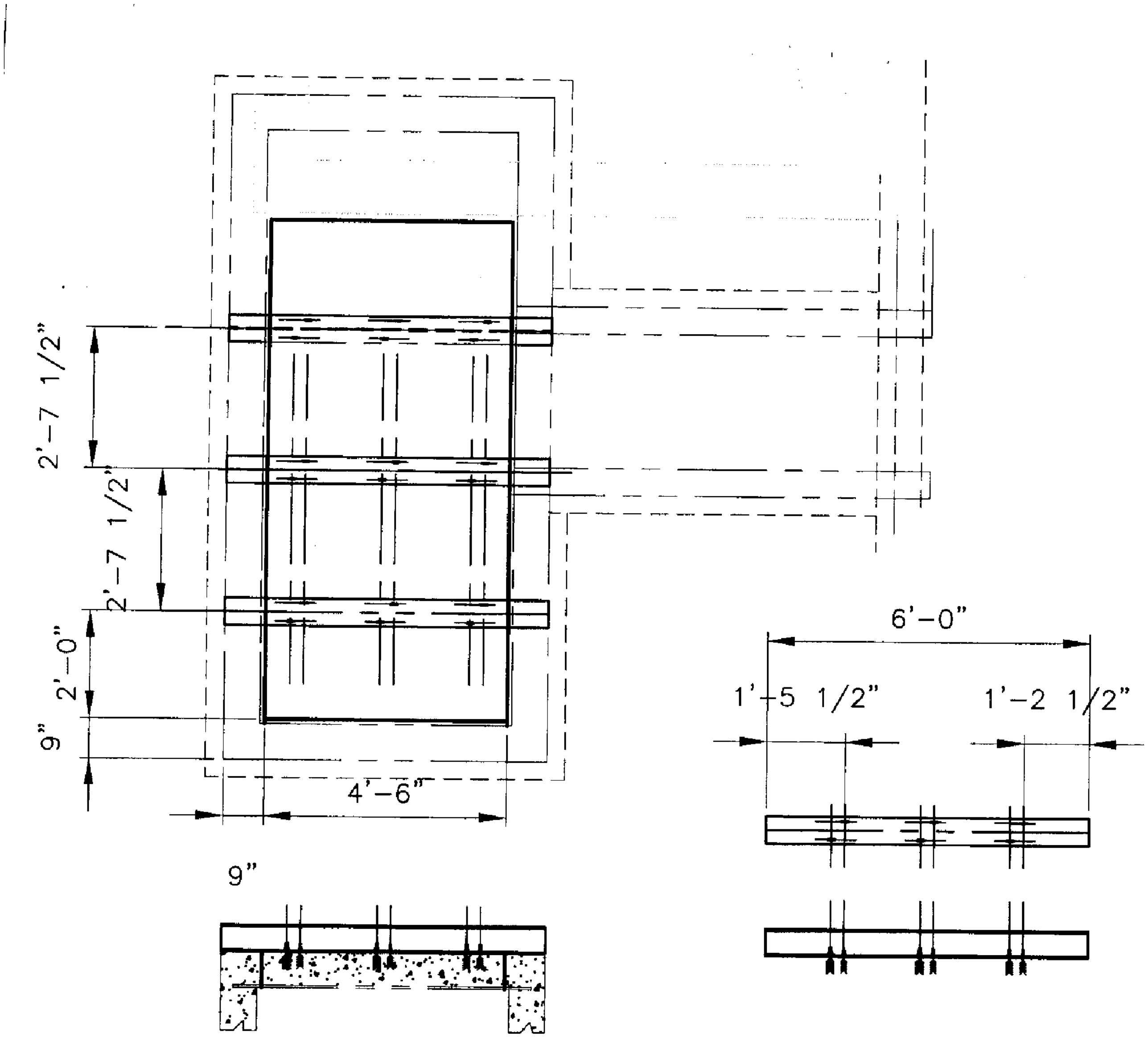
3. Upon completion of cut lines #1 and #2, install the two Lifting/Support Beams as shown, and secure to slab.

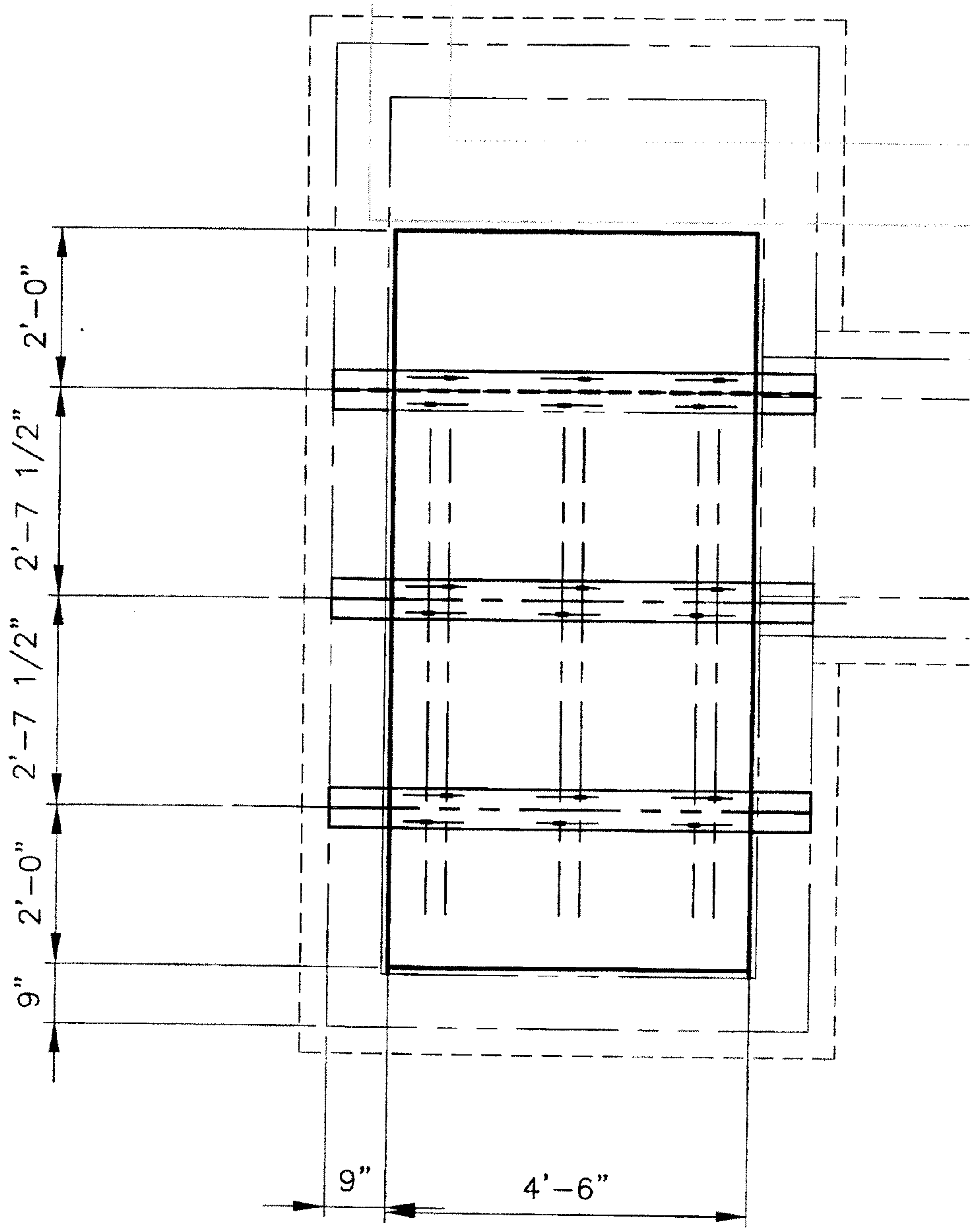
4. Saw cut lines at "A" and "C" from grid lines #1 to #2.

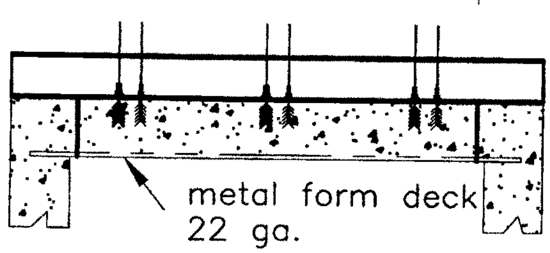





Saw cut lines "A" and "C" upon completion of support beam installation
Install Lifting and Support Beams
A
B
C
1
2
2'-0"
2'-0"


2'–7 1/2"
2'–7 1/2"
2'–0"
9"
4'–6"
9"
6'–0"
1'–5 1/2"
1'–2 1/2"



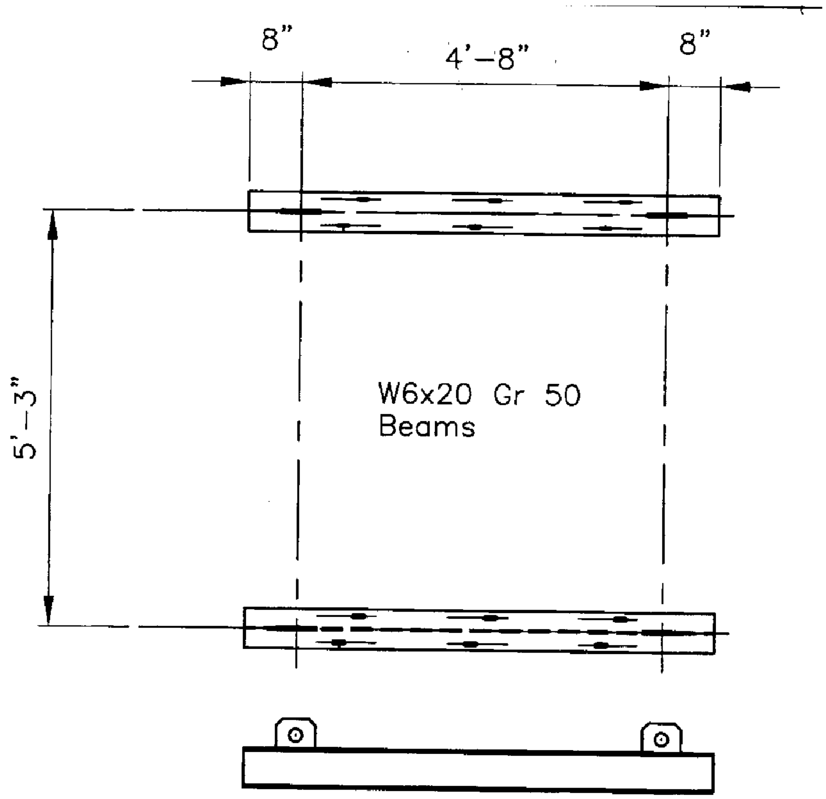


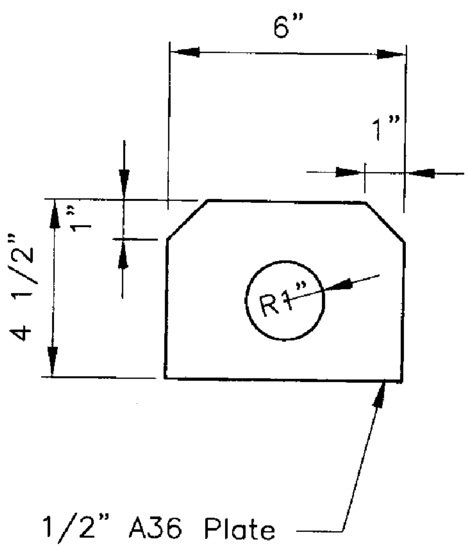
Support Beam
Layout

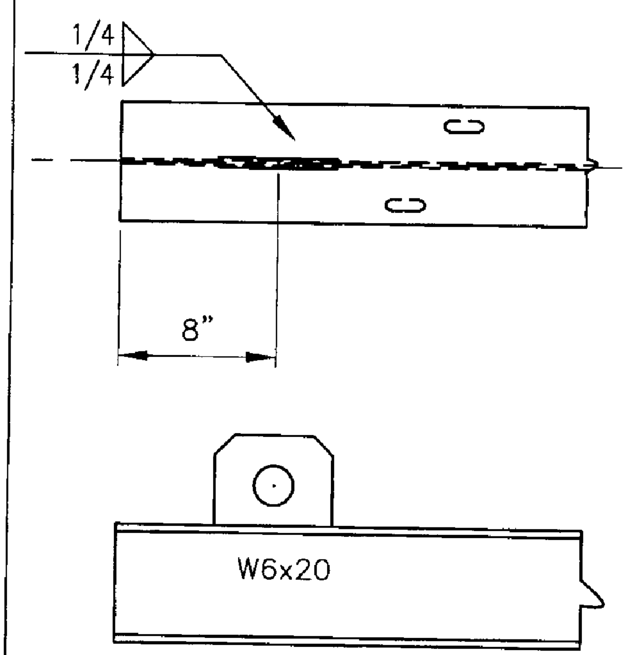
Notes:

1. Spreader Beam shall be used to provide vertical lift.

2. Minimum Sling angle shall be 60 degrees.





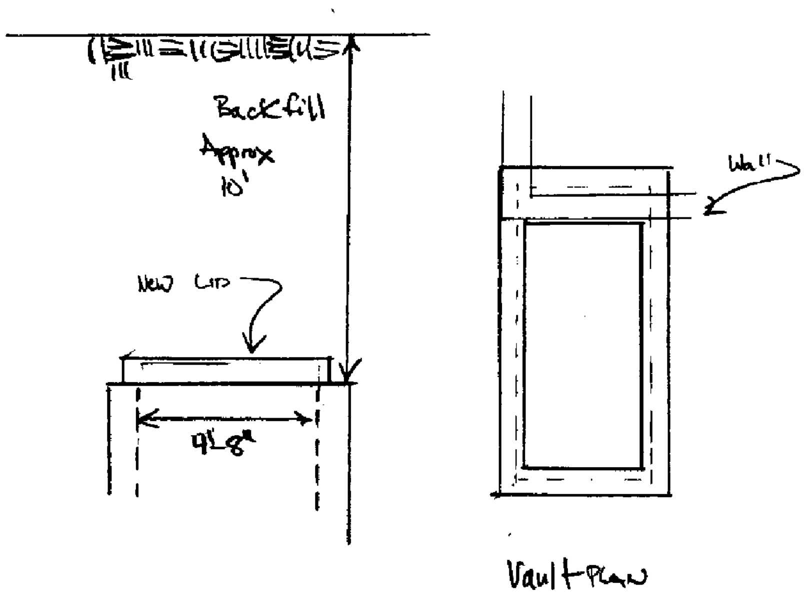


Lifting Bracket Detail

SFE-20 TANK	11/02	P. Bergquist

Precast Vault Lid Design

Design A lid to be placed back on vault after tank has been removed.



- Lid must support soil loads
  Lid must provide support for walls: Since excavation is sloped, walls will not need support during demolition.

Assume γ_{soil} = 115 pcf. Soil wt = 115(10) = 1150 psf

Free span = 4'-8" Concrete wt = 150 pcf/2 = 75 psf (6")

12" strip:

W_u = 1.7(1150) + 1.4(75) = 2060 psf M_u = 2060 $\frac{(4.67)^2}{8}$ = 5616 #-ft
V_u = 1965$\left(\frac{4.67}{2}\right)$ = 4588 #

For a 12" strip: b = 12" d = 6'-2"-.5/2 = 3.75"

$a = \frac{A_s f_y}{.85 f'_c}$ using ρ_{min} = .0033 A_t = .0033(12)(3.75) = .1485 in²

Try #4 @ 12" = .20

SFE-20 TANK	11/02	P. BRAGASSA

Pre-cast Vault LID DESIGN - (cont)

For #4 @ 12" $A_{st} = .20 in^2$ $a = \frac{(.20 in^2)(60 ksi)}{.85(4)(12)} = .294"$

$\phi M_n = \phi A_{st} f_y (d - \frac{a}{2}) = .9(.20)(60)(3.75 - \frac{.294}{2}) = 38.91^{k \cdot in}$

$\phi M_n = 3243^{\#-ft} < M_u = 5357$

No. Good - Need to increase "d"

Try 8" thick. $d = 8 - 2 - .5/2 = 5.75 in$

$\rho_{min} = .0033 (12)(5.75) = .2277 in^2/ft$

Try #5 @ 16" $A_{st} = .23 in^2/ft$

$a = \frac{(.23)(60)}{.85(4)(12)} = .3382$

$\phi M_n = (.9)(.23)(60)(5.75 - \frac{.3382}{2}) = 69.31^{K \cdot in}$

$\phi M_n = 5776.2 \#\text{-ft} > M_u = 5357$ ✓OK

$\phi V_c = (.85) 2 \sqrt{f'c}\, b_w d = (.85) 2 \sqrt{4000} (12)(5.75) = 7418.7^{\#}$ ✓OK $> V_u = 4535^{\#}$
concrete only.

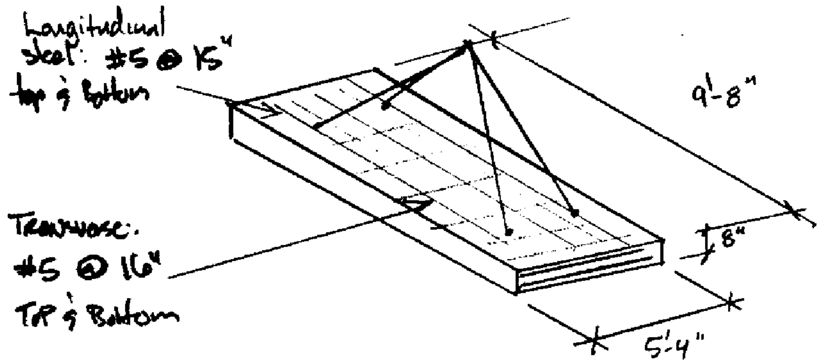
∴ USE 8" thick slab reinforced w/ #5 @ 16" (bottom)
transverse steel # 4 @ 12" $A_{st} = .20$ or #5 @18
$A_{st} = .21$

$\rho = 0.0018$; $A_{st} = .0018 (8 \times 12) = .17$

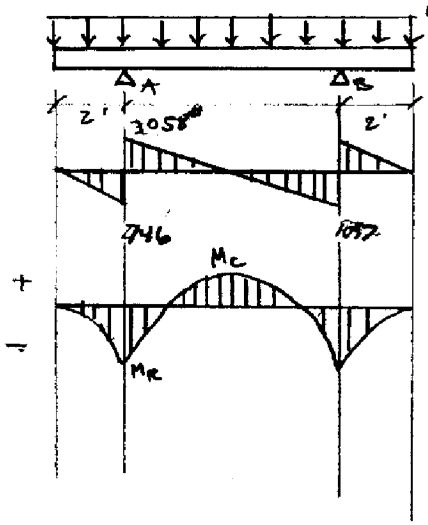
SLAB will be pre-cast (site cast) and lifted into place.
This may be critical condition for Reverse bending stresses in top section of slab.

SSE-20 TANK | 11/02 | P. Bragassa

Pre-cast Vault LiD DESIGN



Critical Plane thru long axis:



$w_u = 100\text{psf}(1.4) = 140\text{ psf}$

$W_u = 140\text{psf}\ \frac{5'4"}{2} = 373\text{ plf}$

$V_F = 373(2') = 746^{\#}$

$R_A = 373\frac{(9.67)}{2} = 1804^{\#}$

$V_A = 1804 - 746 = 1058^{\#}$

$373(5.67) - 1058 = 1058^{\#}$

$R_B = 1804$

$M_e = -373\cdot\frac{(2)^2}{2} = 746\ \#\text{-ft}$

Max: + = 2755 #-ft (TOP steel)
Max − = −2730 #-ft (Bottom)

$M_c = \frac{373(9.67)}{8}\left(9.67 - 4(2)\right)$

$M_c = 753\ \#\text{-ft}$

Using 2" Cover $d = 8" - 2 - .25 = 5.75\text{in}$

$\rho_{min} = .0033(12)(5.75) = .227$ ∴ use #5 @ 16 $\phi M_n = 5776\ \#\text{-ft}$

OR For even Spacing: 5'4" − 2" − 2" (cover) = 5' = 60", use #5 @ 15" max.

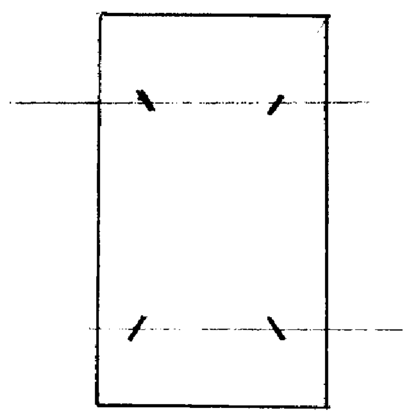
SFE-20 TANKS | 11-02 | P. BRAGASSA

RIGGING FIXTURE DESIGN - Vault LID

SLAB weight = $9.67' \times 5.33' \times .67' \times 150\,pcf = 5180^{\#} \approx 5200^{\#}$

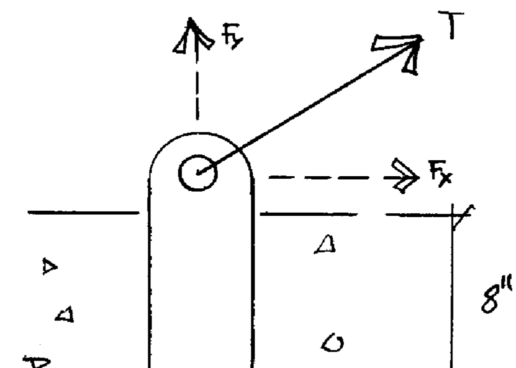
4-Point Lift will be used, 2 legs will be assumed to support entire load as a minimum (DOE-STD-1090_ Section 11.31.2)

Assume a single point of attachment (No spreader Beam used) And 60° Angle for slings



Vault Lid will be set and only removed when vault is demolished. There fore, not necessary to used removable, and replaceable lifting inserts. (difficult to install)

Use Fabricated Plates.



extend to bottom of vault lid. This will be much easier to install, since it will set on form.

$F_y = \frac{1}{2} P = \frac{5200}{2} = 2600^{\#}$

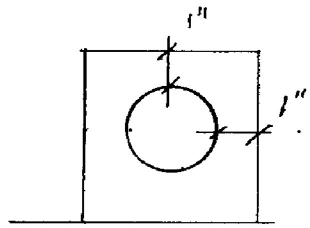
$T = \frac{2600}{\sin 60°} = 3002^{\#}$ @ 60° $\quad F_x = 1501^{\#}$

$T = \frac{2600}{\sin 45} = 3677^{\#}$ @ 45° $\quad F_x = 2600$ @ 45°

SFE-20 TANK	11-02	P. BRYCASS(?)

VAULT LID DESIGN – cont

USING A 2" hole and Assume 1/2" plate



$A = (.5)(1) = .5 \, in^2$

$F_v = .3 F_u$ (AISC J4-1)

$F_v = .3(58) = 17.4$ Ksi

OR F.S. 3:1 on Yield

$F_v = \frac{36}{3} = 12$ Ksi

Use HIGHER Factor of Safety Value.

Allow $V = P = F_v A$

Shear Force: 12Ksi (.5)

= 6 Kips ✓ OK

For 3/8" Plate: $A = .375(1) = .375 \, in^2$

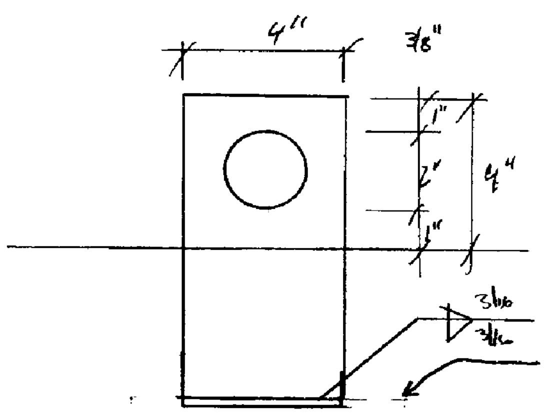
$P_{all} = 12(.375) = 4.5^{Kips}$ ✓ OK

$R = 0.3 F_u A_v + 0.5 F_u A_t$ (Block Shear equation Based on J4)

$R = .3(58)(.375) + (.5)(58)(.375) = 17.4^{Kips}$

$R = 4.5 + \left(\frac{36}{3}\right)(.375) = 9^{Kips}$ OK

use 3/8" CS plate with minimum 1" Material around Hole.



4x4x1/4 Plate

For Welds

3/16" Fillet

$P = .707(3/16)(70)/3$

$P = 2.78 \, K/in$ ✓ OK

SFE-20 TANKS	11-02	P. BRAGASSA

Vault LID Design- Cont

Check Embedment:

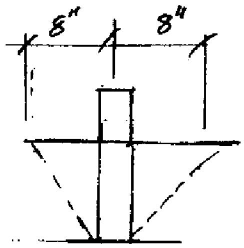
for Impact

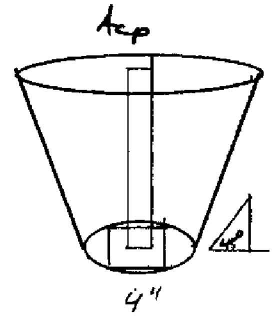
$N_u = 2600^{\#}(1.7) = 4420^{\#}$

$h_{ef} = 8''$ (embedment)

$P_d = 4\phi\sqrt{f'_c}\,A_{cp}$ (ACI 349 B.4.2)

$A_{cp} =$



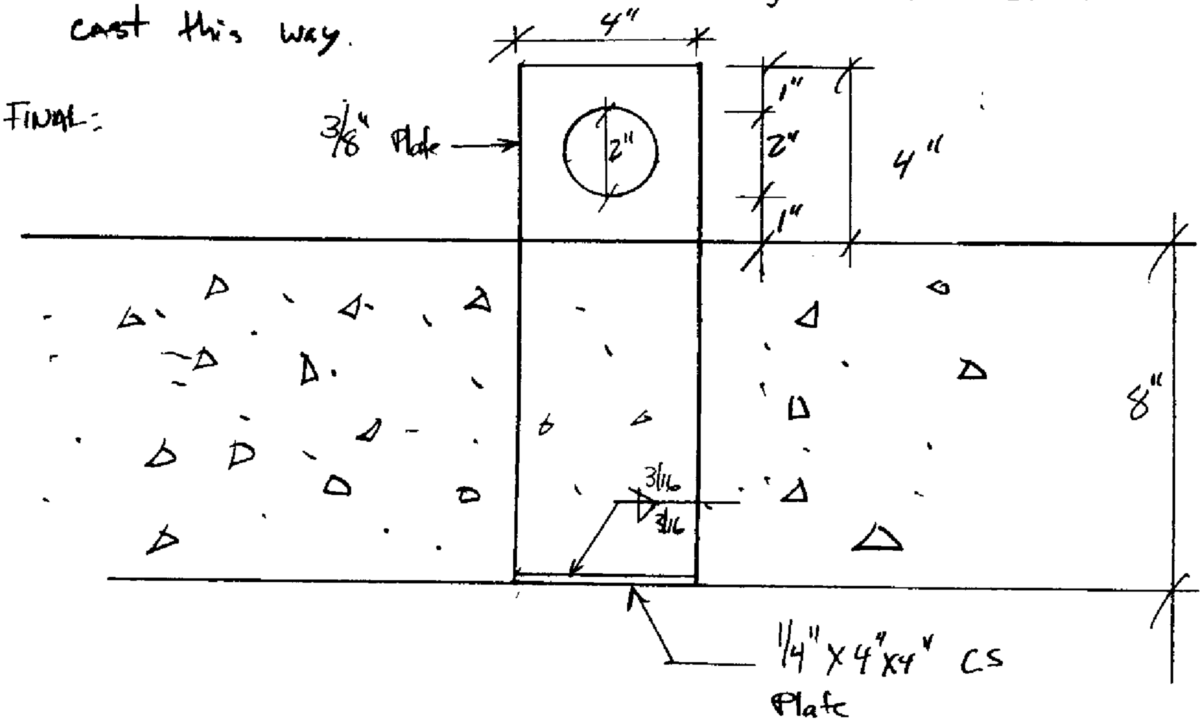


$A_{cp} = \pi\,(8)(4)^2 = 402.12\ in^2$

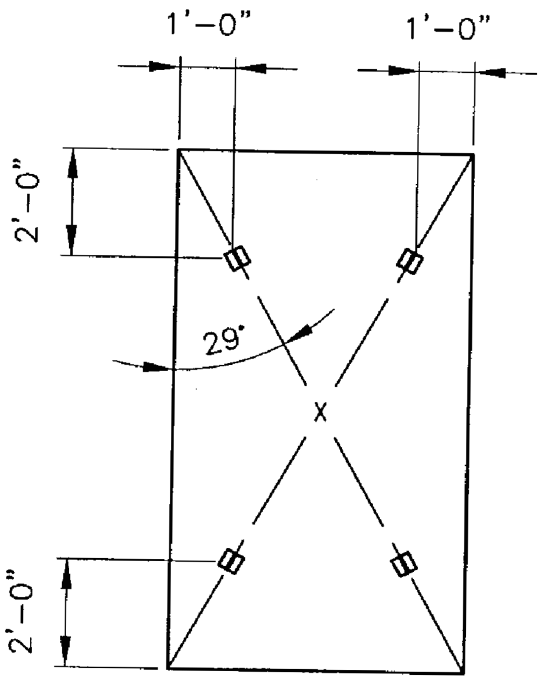
$P_d = 4(.65)(\sqrt{4000})\,402. = 66.12^K$ ✓ok

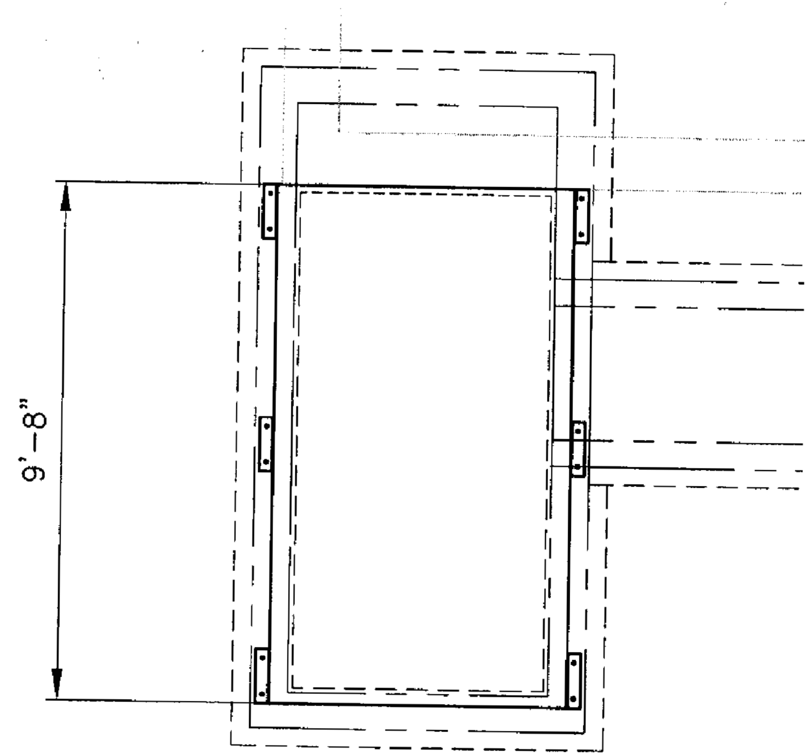
- Plate doesn't need to extend to bottom, but for easier to cast this way.

FINAL:

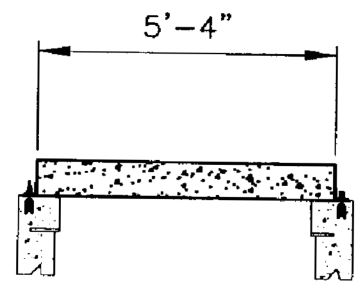


ENGINEERING DESIGN FILE

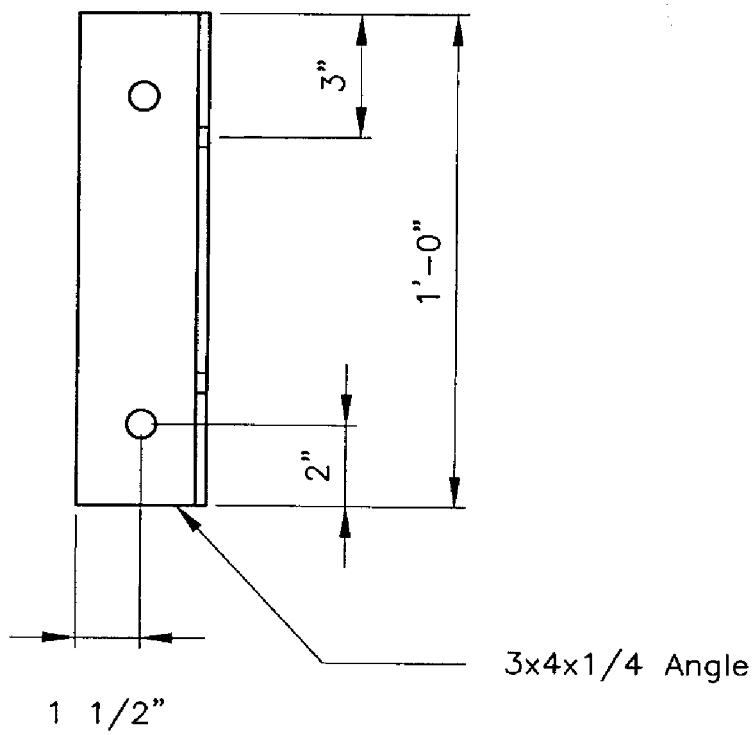


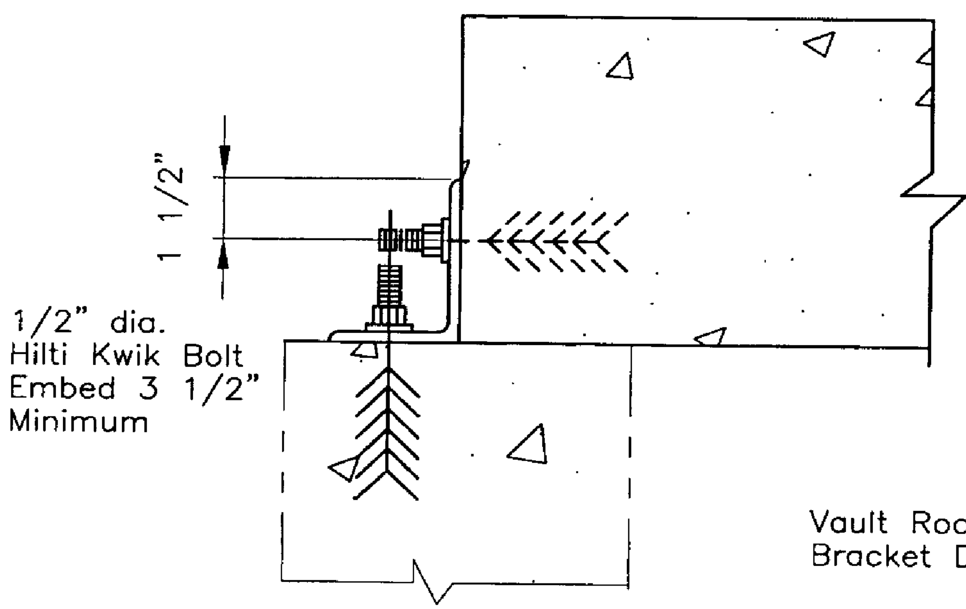


Reinforcing:
#5 Bars at 15"
on center, each way
top and bottom.
2" clear cover



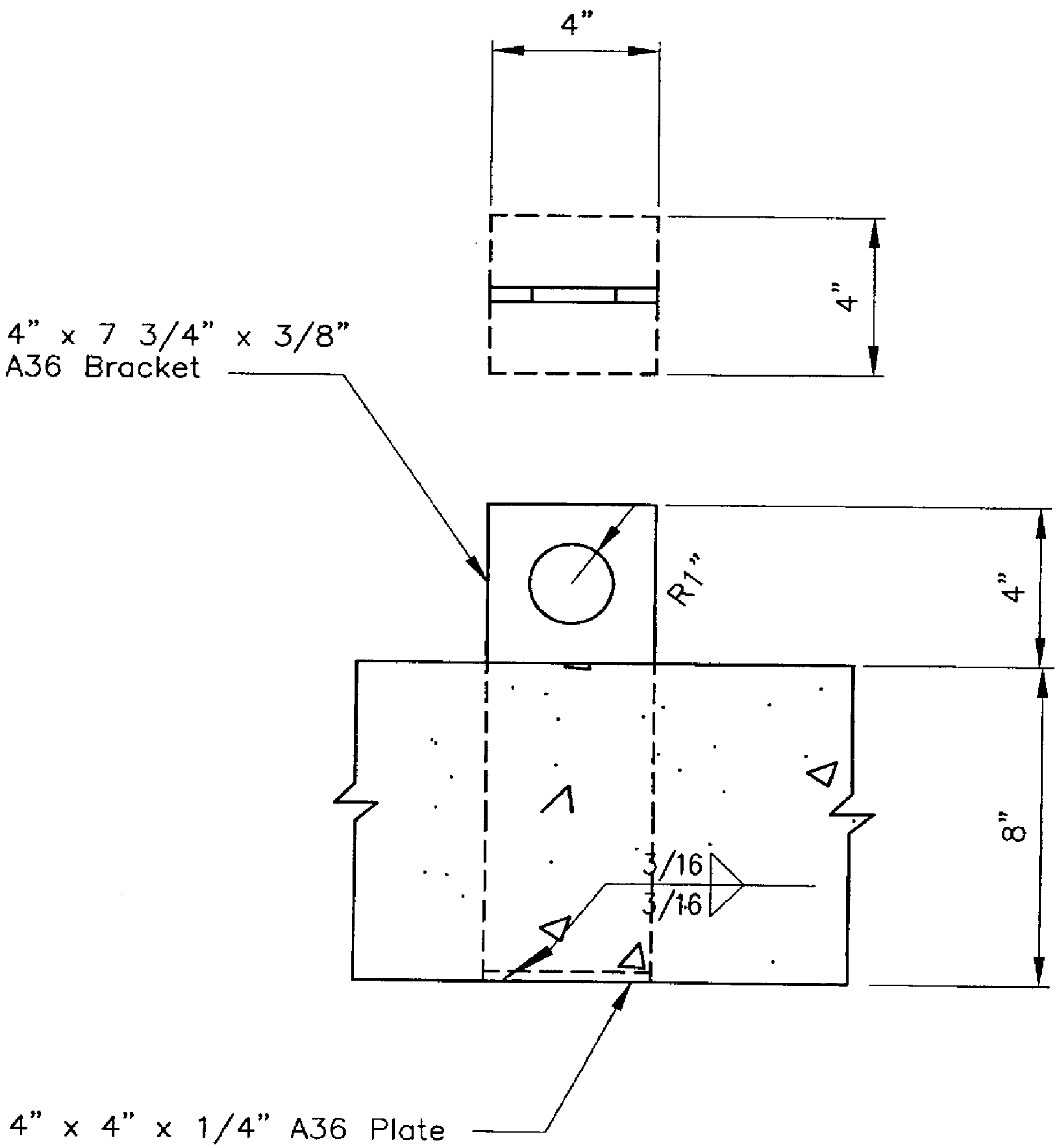
Estimated lifting weight of Slab: 5,160 pounds





Vault Roof Connection
Bracket Detail 6 Req'd

Vault Roof Lifting Bracket

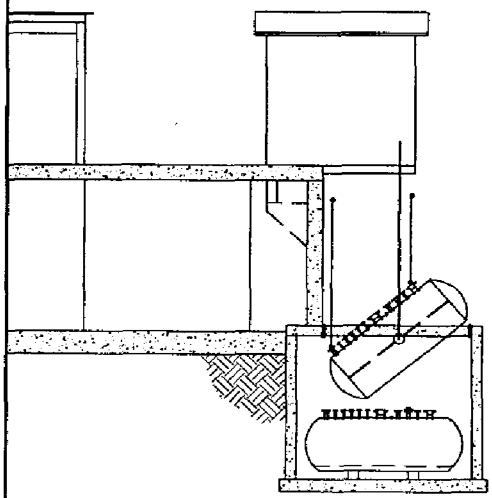


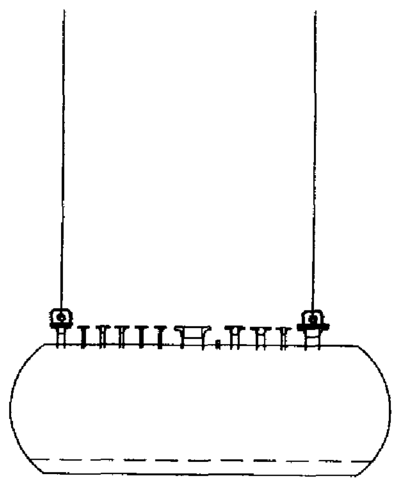
TANK SFE–20 Removal Analysis and Rigging Design.

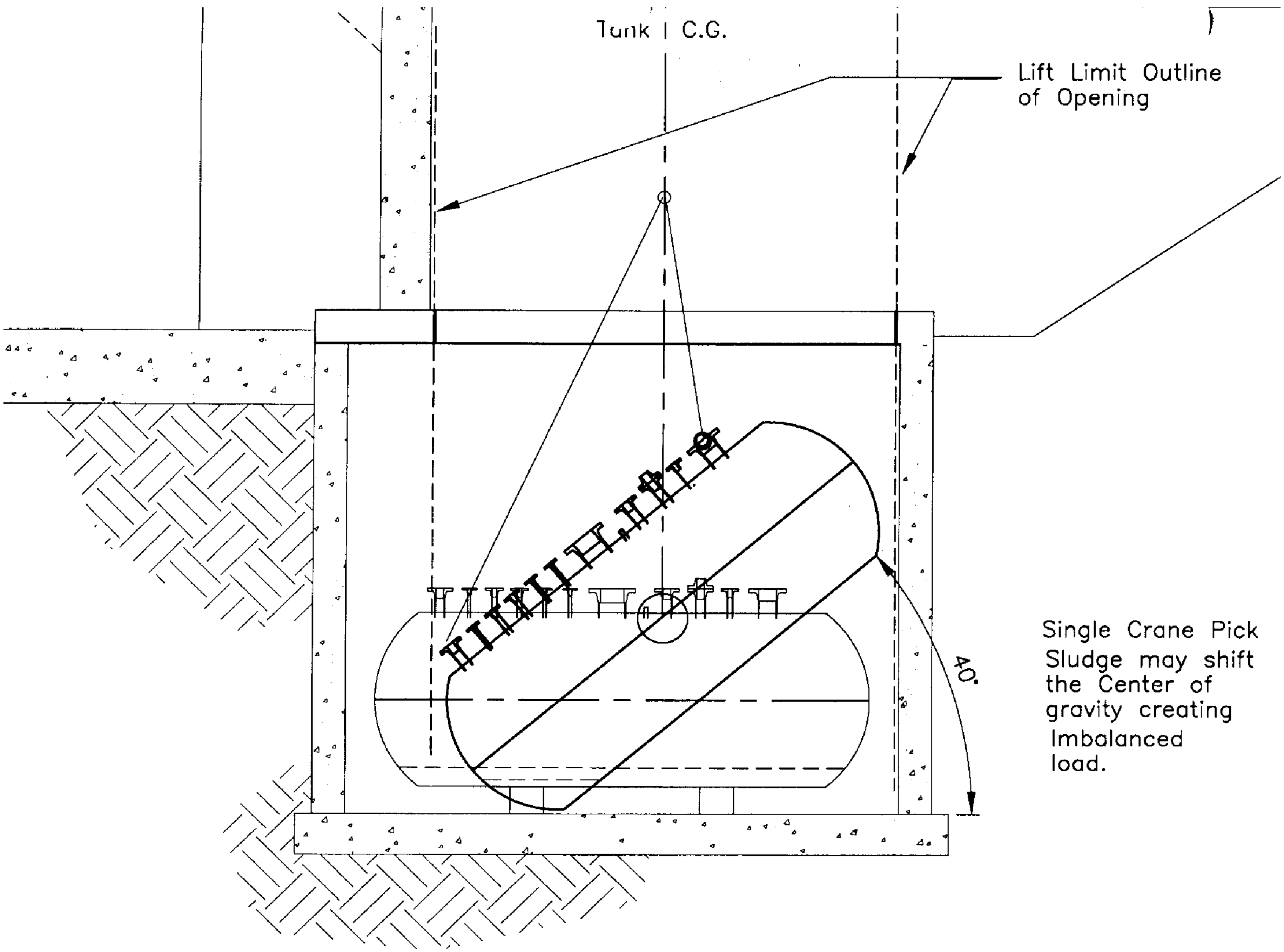
The SFE–20 tank will be removed through a hole cut into the roof of the concrete vault, approximately 10 feet below grade. Due to interferences with an adjacent wall, the hole in the roof will be slightly smaller than the tank and will require tilting the tank during the lift.

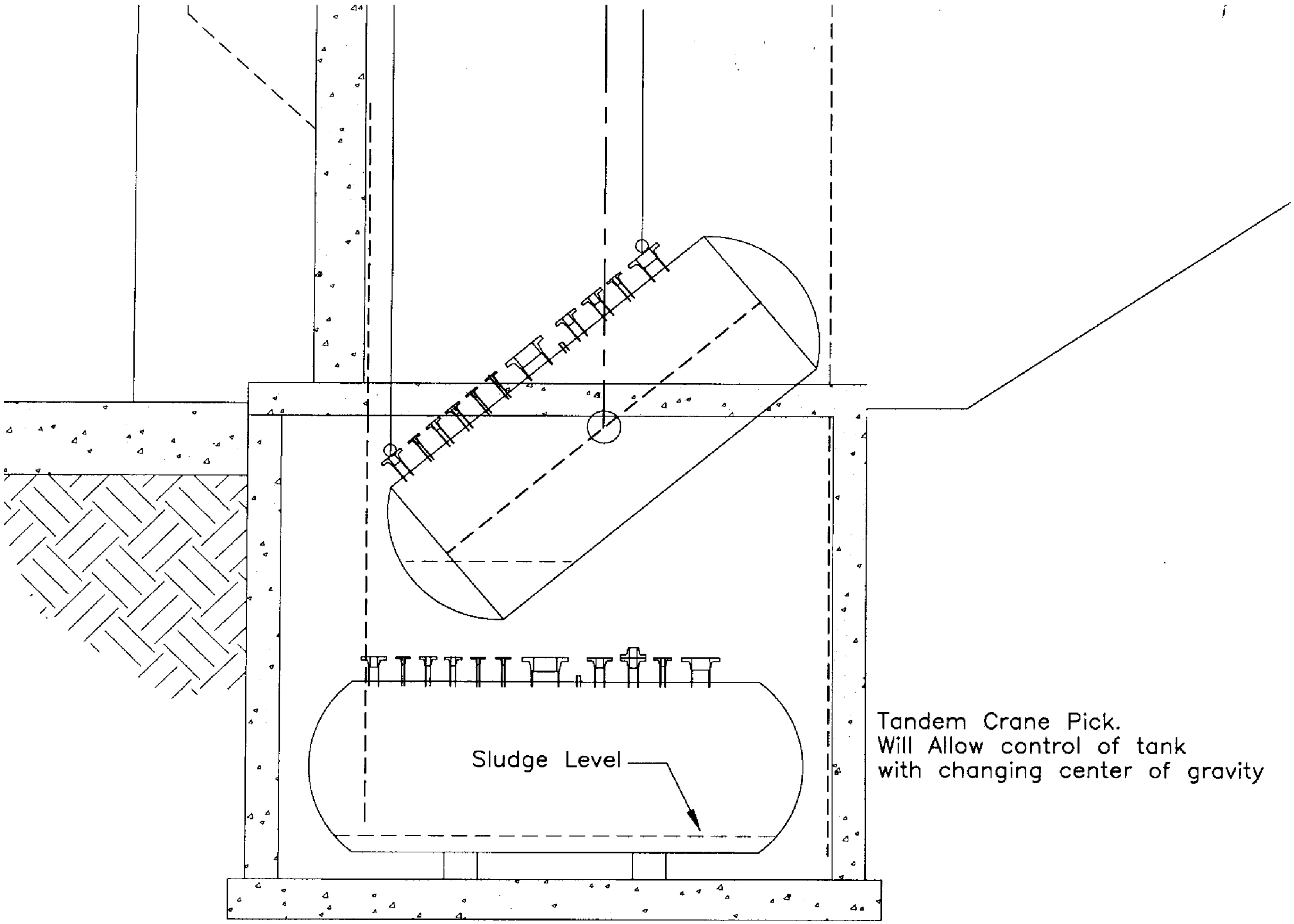
The concrete vault in which the tank sets provides very little clearance on the sides and ends. Since the vault clearance restricts access under the tank, the rigging to be used to remove the tank must be attached from the top, which will provide the best control during the angled lift. The existing pipe flanges, which are located on the centerline of the tank top will be used for attachment of the rigging.

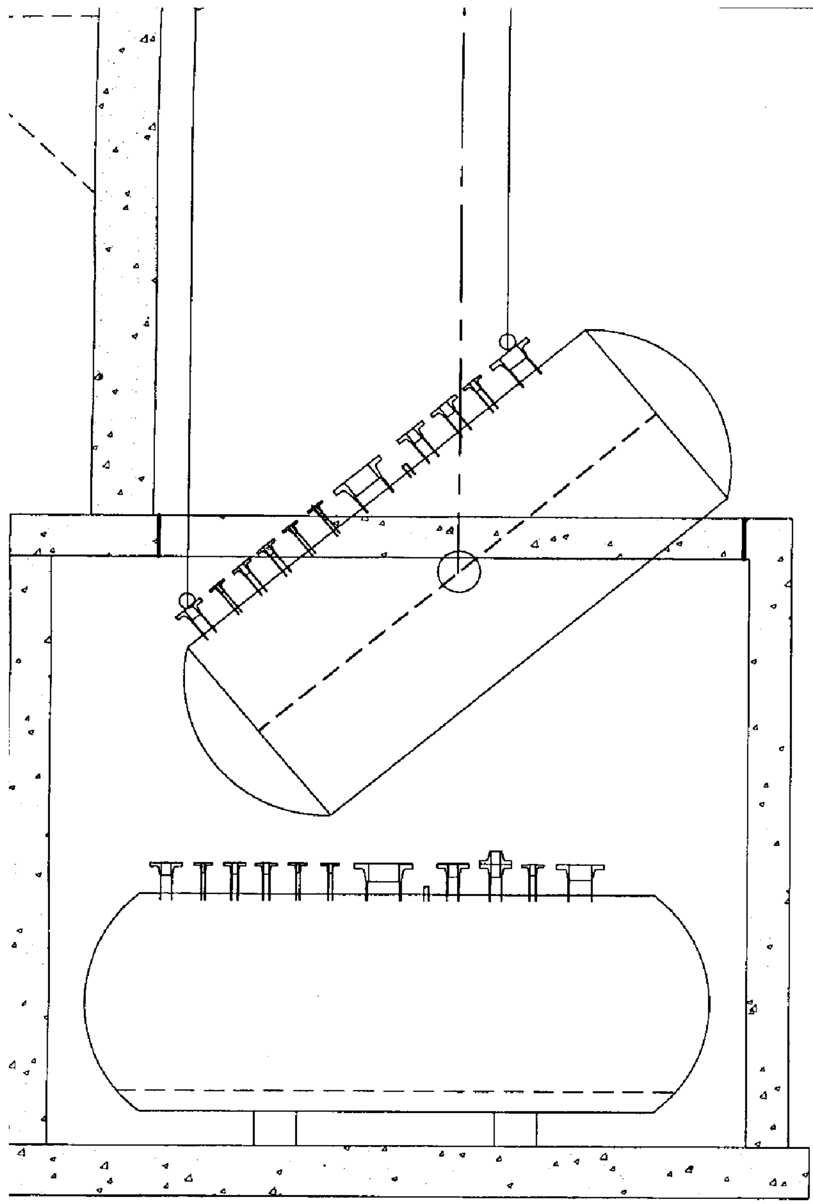
The tank was modeled using STAA.Pro 2001, a computer based finite–element analysis program. The tank loads were applied and the resulting stresses were determined. Lifting brackets were designed that attach to the blank pipe flanges that will be installed on the pipes once disconnected from the pipes.






Tank | C.G.
Lift Limit Outline
of Opening
40°
Single Crane Pick
Sludge may shift
the Center of
gravity creating
Imbalanced
load.


Sludge Level
Tandem Crane Pick.
Will Allow control of tank
with changing center of gravity



Angled Lift Analysis

Calculated weight of tank including interior piping = 1,550 #.

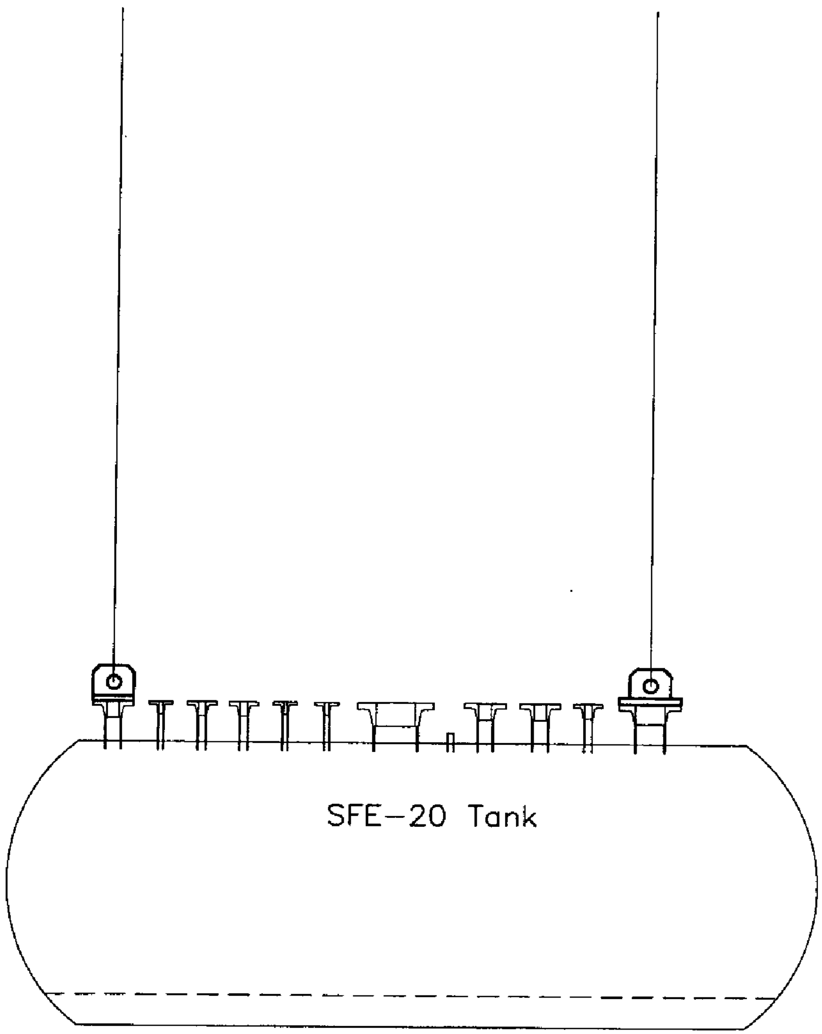
Given weight of sludge = 371 #
round to 400 #
For finite lement modeling, distribute sludge weight to 40 nodes throughout the bottom of tank = 10# /node.
Total weight = 1,950 #

STAAD/Pro calculated weight = 1223 # (does not include misc weights)
Factor for adjustment: 1550/1223 = 1.26 used for selfweight calculation in STAADPro.

Self weight of tank will be applied at an angle of 40° by using Fy and Fz components: Selfweight is applied by finite-element program (STAAD/Pro). Factor of 1.26 adjusts tank weight to account for piping and modeling.

$FY = 1.26(\sin 40°) = 0.81$

$FZ = 1.26(\cos 40°) = 0.965$



Level Lift Analysis

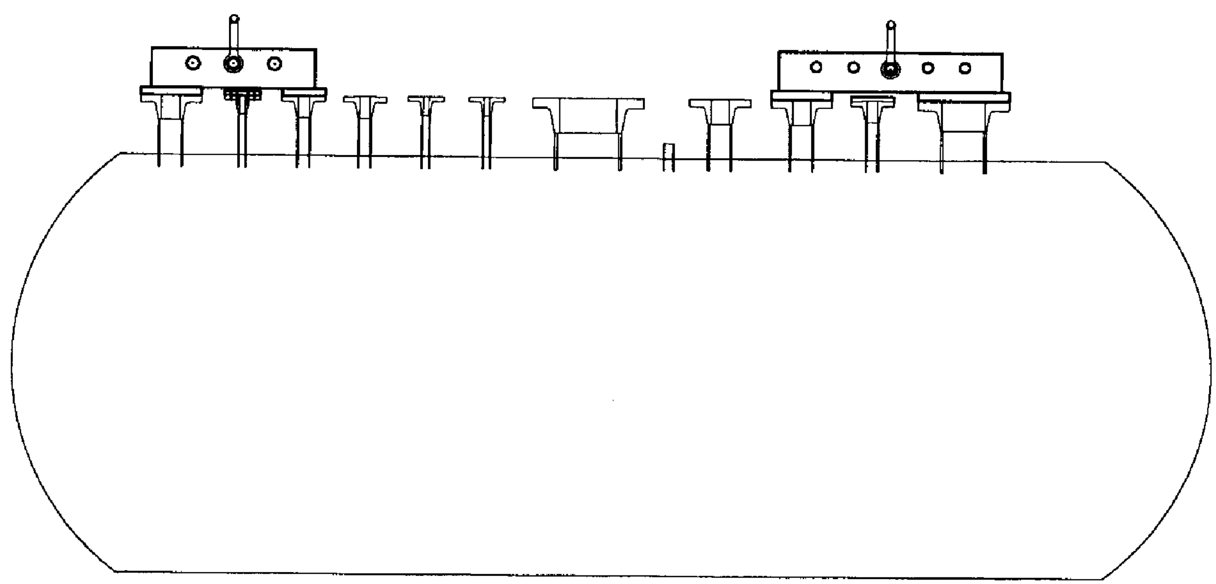
Calculated weight of tank including interior piping = 1,542 #.

Given weight of sludge = 371 #
round to 400 #
For finite lement modeling, distribute sludge weight to 40 nodes throughout the bottom of tank = 10# /node.
Total weight = 1,942 #

STAAD/Pro calculated weight = 1223 # (does not include misc weights)
Factor for adjustment: $\frac{1542}{1223} = 1.26$ used for selfweight calculation in STAADPro.

Prelimenary analysis determined that by rigging to only the end two flanges (2" and 4" diameter) resulted in stresses at the tank connection in excess of the required factor of safety of 3:1 on yield. Due to the contamination of the contents of the tank, the stress levels were judged to be unacceptable. The design was then modified to allow lifting the tank using a total of four pipe flanges.

The analysis was performed on both a level tank lift and an angled lift to simulate the actual required field conditions. The maximum stresses occurred during the angled lift. The maximum rsulting stresses in the tank were found to be 8.12 ksi which is acceptable. The STAAD/Pro analysis and results are included in this EDF.



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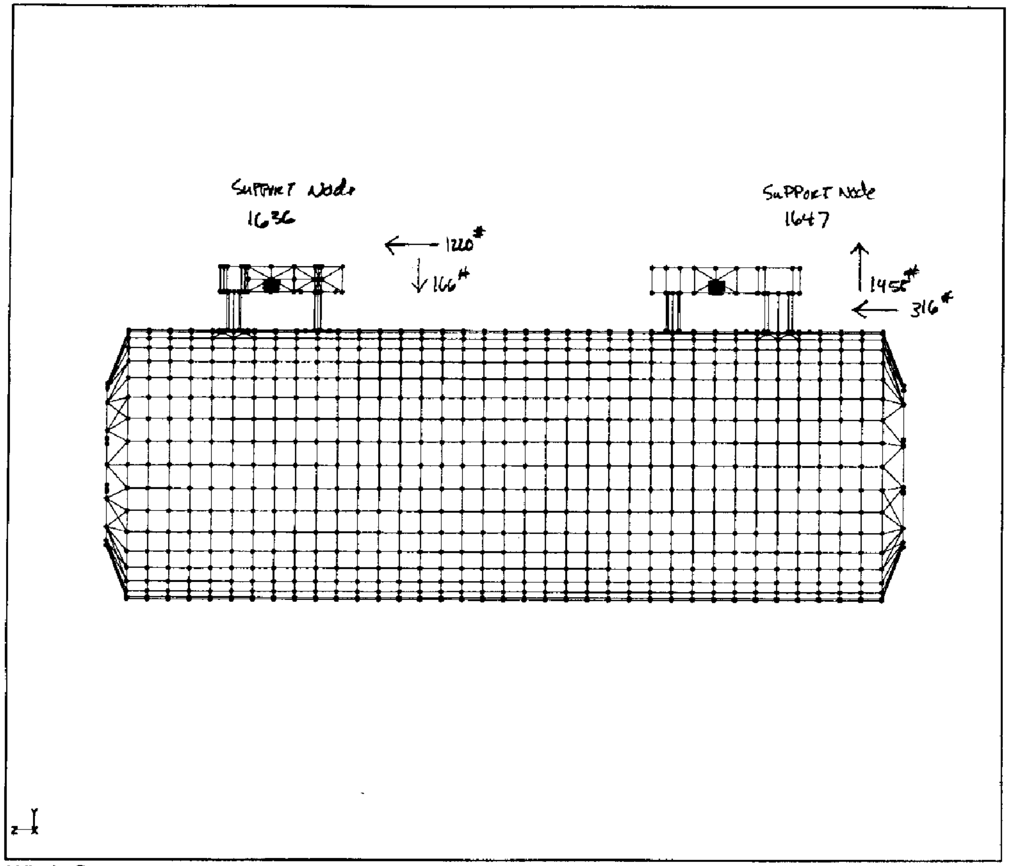
SFE-20 Tank Removal Angle Lift

Job Title	Job No	Sheet No 7	Rev
	Part		
	Ref		
	By	Date 29-Oct-02	Chd
Client	File sfangle2.std	Date/Time 05-Nov-2002 16:07	

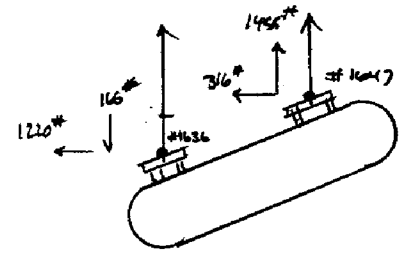


Whole Structure

SFE-20 Tank	11/02	P. Bragassa

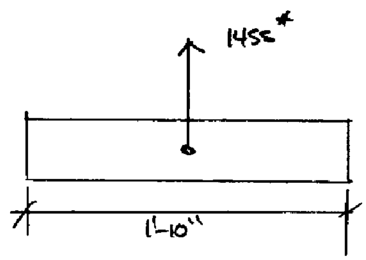
Tank Rigging

STAAD/PRO ANALYSIS:



From Reactions on pg 2 of STAAD output

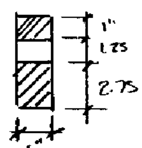
Max Bending in bracket



check both Fixed & Pinned Conditions

$M = 1455\,\frac{(22")}{4} = 8003\ \#\text{-in}$

$M = 1455\,\frac{(22)}{8} = 4001\ \#\text{-in}$



IF Stress occurs at hole, assume only bottom section.

$I = \frac{(1)(2.75)^3}{12} = 1.73\,in^4 \quad S = \frac{I}{c} = \frac{1.73\,in^4}{\frac{2.75}{2}\,in} = 1.26\,in^3$

$f_b = \frac{8003\ \#in}{1.26\,in^2} = 6352\ psi$ ✓OK $< 12\,Ksi$

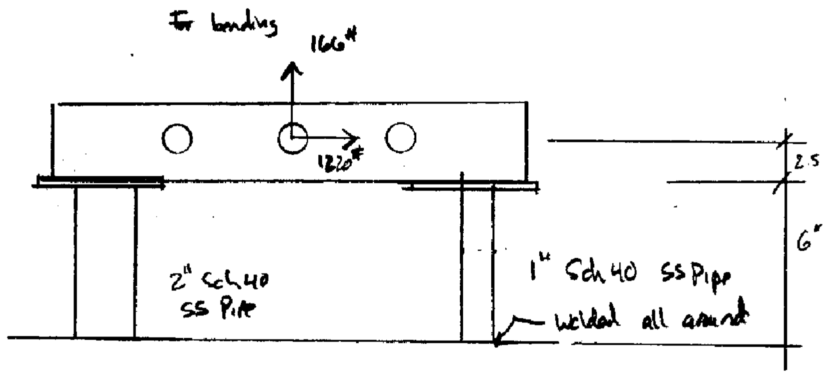
Welds: use code minimums, since a 1" thick material used. Could use a thinner plate, but due to uncertainties with Rigging & Lifting, it is a good idea to over design fixture to account for field variations.

For 1" thick plate, Table J2.4 of AISC Requires a minimum Fillet weld of 5/16"

$P = .707\,(5/16)(.3)(70) = 4.64\ K/in.$ use 5/16"

SFE-20 TANK | 11/02 | P. Bragassa

USE MAX SUPPORT LOAD:



Max Bending at Pipe base:

FROM STAAD: 8.12 KSi

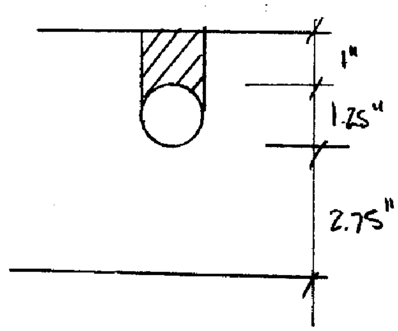
For 304L Stainless $F_y = 30$ KSi $\quad F.S = \frac{30}{8.12} = 3.695$ ✓OK (>3)

Max tension = 1455# ↑

Shear = 1220# ←

Check bracket:

1" Thick x 4" A36 C.S. Plate



Shear area:
1" x 1" x 2 planes
$= 2\,in^2$

For A36 Steel
$F_y = 36$ KSi

F.S. for Hoisting & Rigging
3:1 on Yield

$\therefore F_v = \frac{P}{A} = 2\,in^2 \left(\frac{36}{3}\right)$
$= 24$ kips

Shear OK.

1" Bracket needed for stiffness only to support between flanges.

SFE-20 Tank	11/02	P. Bragassa

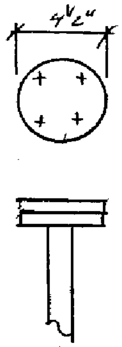
Tank Rigging - Continued.

Flange Plate Bolts:

Bolts:

Total tank wt = 1942#
say 2000#

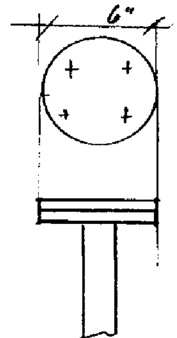
The basket supported by the 2" and 1" pipe flanges will be supported by 4 bolts on each flange:



1"

(4) ½"φ bolts

Shear cap = 4 x 1.94 = 7.76K
(each bolt capable of withstanding load)



2"

(4) 5/8" φ bolts

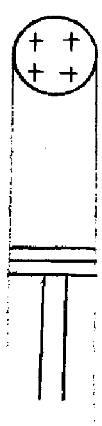
Shear cap = 3.1 x 4 = 12.4K

Table I-B AD AISC
Assume bolts A307 (Conservative)

Allowable Tension ½" = 3.76 K / bolt
5/8 = 5.9K / bolt

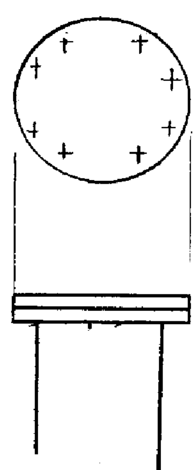
Allow Shear: ½ = 1.94K / bolt
5/8 = 3.1K / bolt

Max shear = 1220# ✓ok
Max tension = 1455# ✓ok



2" pipe

(4) ½" Bolts



4" Pipe

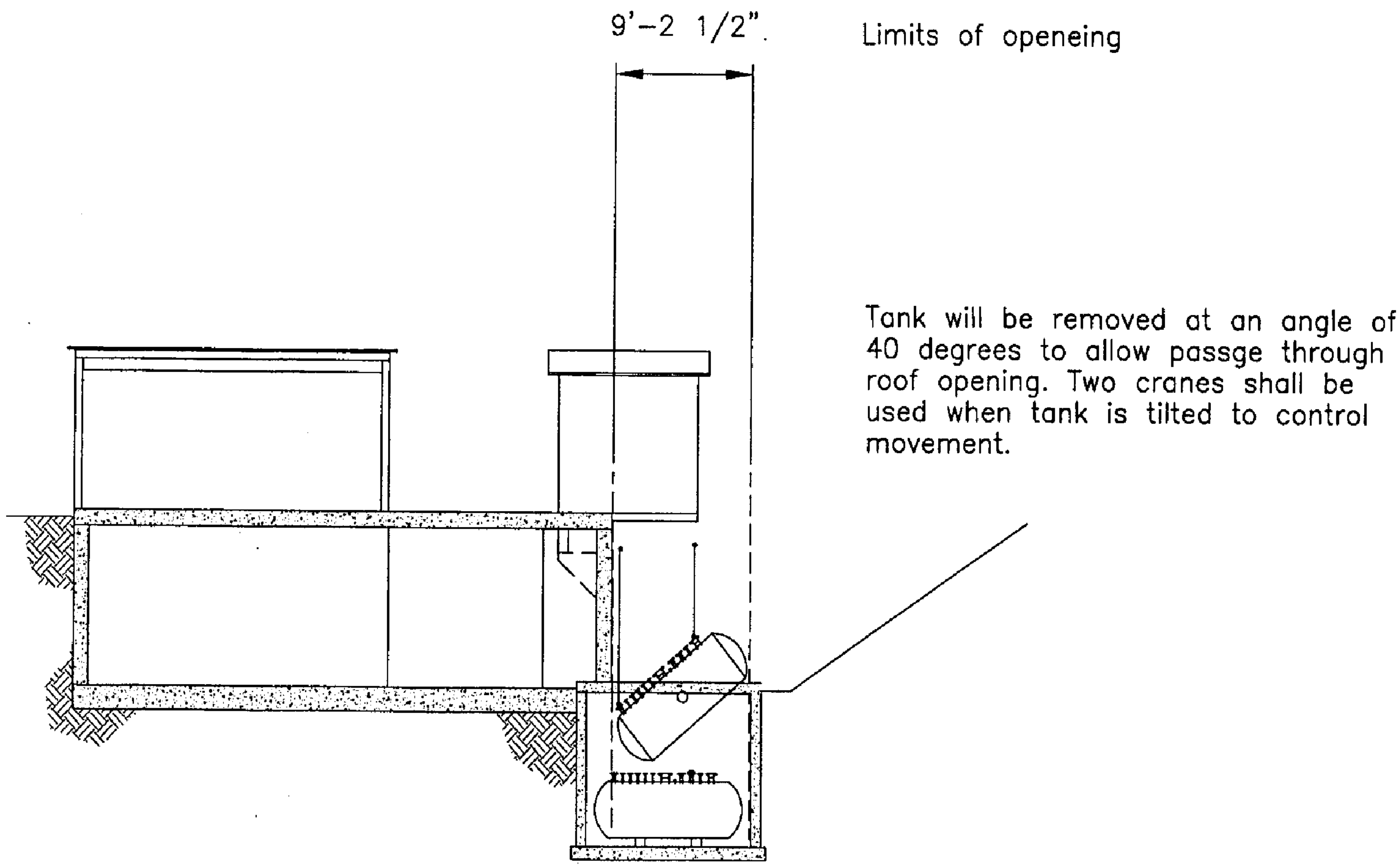
(8) 5/8" bolts

Allowable Values: (Bolts)

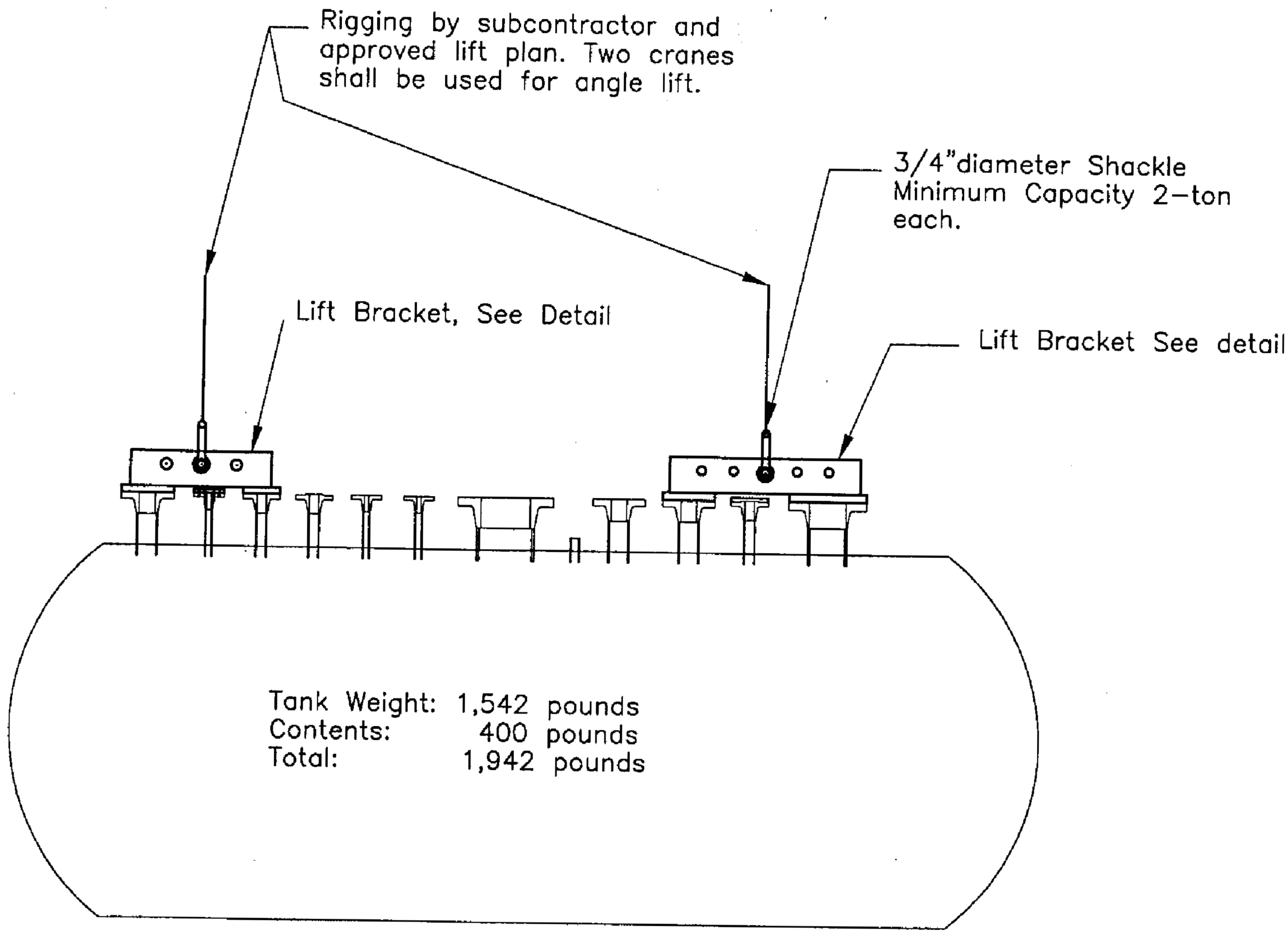
2" Flange: (4 bolts) ½"
Shear Cap = 4 x 1.94K = 7.76K
Tension = 4 x 3.76 = 15.1K

4" Flange:
Shear = 8 x 3.1 = 24.8K
Tension 8 x 5.9 = 47.2K

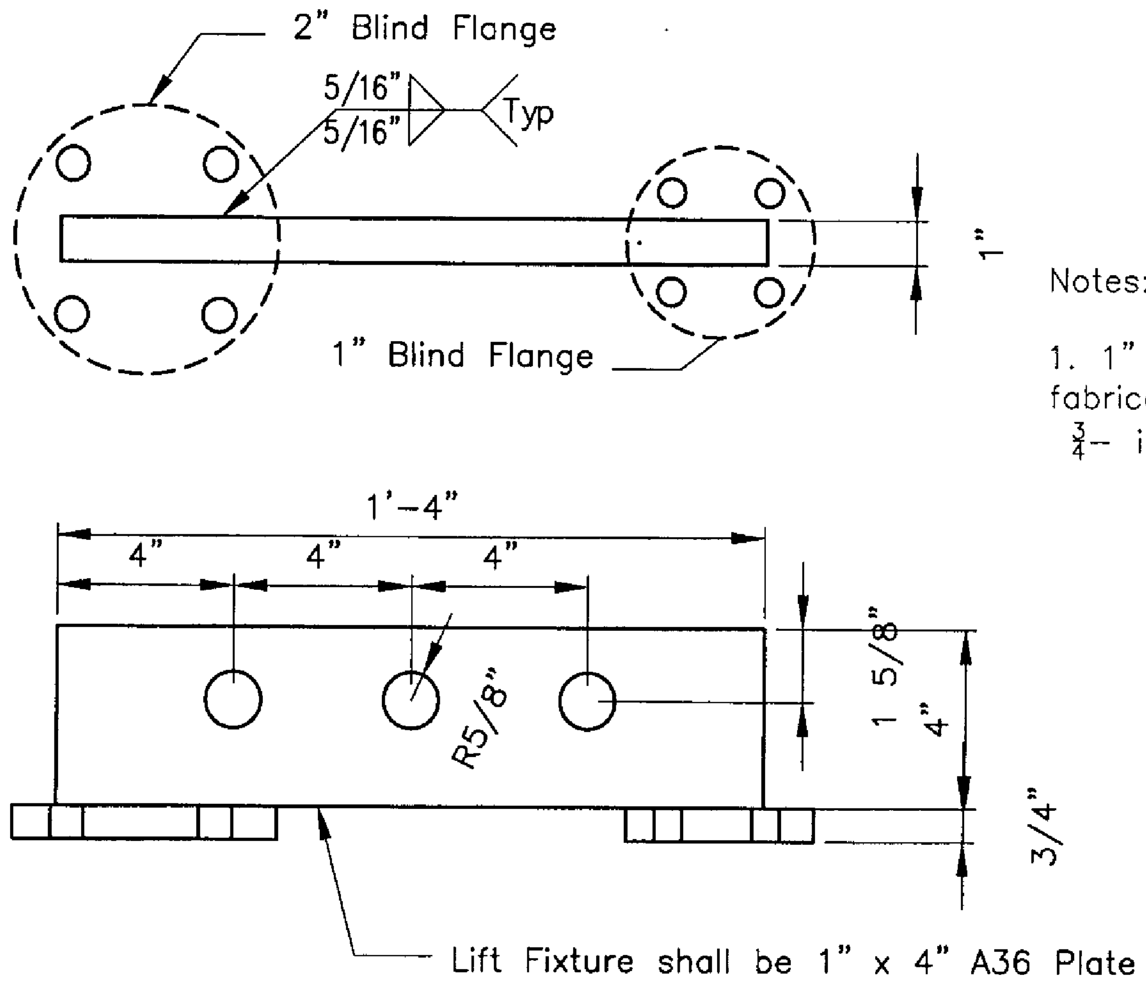
Use ½" bolts for 2" and 5/8" for 4" flange.
A307 as minimum ✓


9'–2 1/2".
Limits of openeing
Tank will be removed at an angle of 40 degrees to allow passge through roof opening. Two cranes shall be used when tank is tilted to control movement.

Tank SFE-20 Rigging

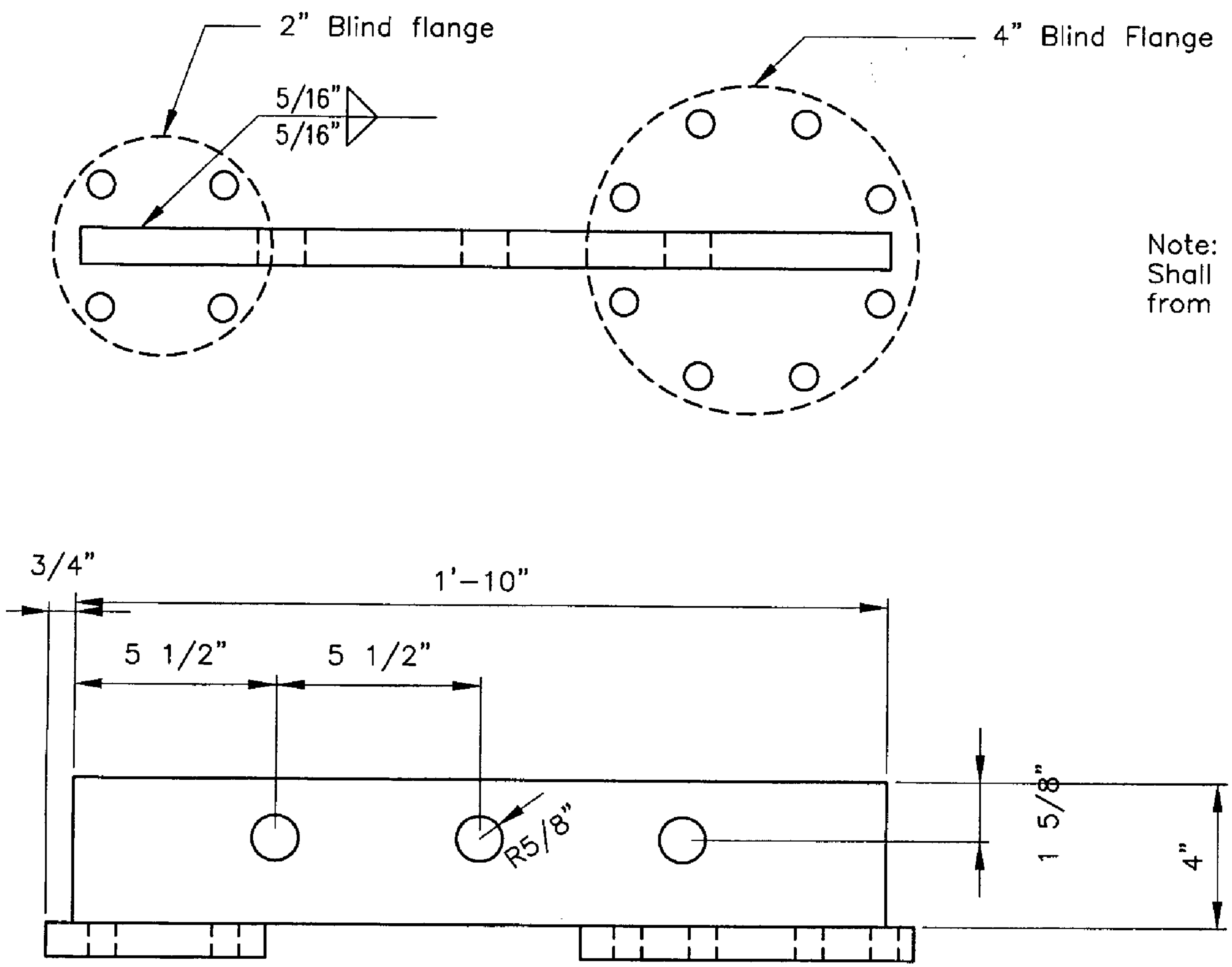


Lifting Bracket–Tank Removal



Notes:

1. 1" Blind Flange shall be fabricated from $\frac{3}{4}$– inch A36 Plate.

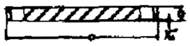


Note: 2 " Blind Flange
Shall be fabricated
from 15/16 A36 Plate to

Lift Bracket–Tank Removal

ENGINEERING DESIGN FILE

BLIND FLANGES



NOM PIPE SIZE	150 LB. Outside Diam of Flange O	150 LB. Thickness Q(1)	300 LB. Outside Diam of Flange O	300 LB. Thickness Q(1)	400 LB. Outside Diam of Flange O	400 LB. Thickness Q(2)	600 LB. Outside Diam of Flange O	600 LB. Thickness Q(2)
1/2	3 1/2	7/16	3 3/4	9/16	For sizes 3 1/2 and smaller use 600 Lb. Standard		3 3/4	9/16
3/4	3 7/8	1/2	4 5/8	5/8			4 5/8	5/8
1	4 1/4	9/16	4 7/8	11/16			4 7/8	11/16
1 1/4	4 5/8	5/8	5 1/4	3/4			5 1/4	13/16
1 1/2	5	11/16	6 1/8	13/16			6 1/8	7/8
2	6	3/4	6 1/2	7/8			6 1/2	1
2 1/2	7	7/8	7 1/2	1			7 1/2	1 1/8
3	7 1/2	15/16	8 1/4	1 1/8			8 1/4	1 1/4
3 1/2	8 1/2	15/16	9	1 3/16			9	1 3/8
4	9	15/16	10	1 1/4	10	1 3/8	10 3/4	1 1/2
5	10	15/16	11	1 3/8	11	1 1/2	13	1 3/4
6	11	1	12 1/2	1 7/16	12 1/2	1 5/8	14	1 7/8
8	13 1/2	1 1/8	15	1 5/8	15	1 7/8	16 1/2	2 3/16
10	16	1 3/16	17 1/2	1 7/8	17 1/2	2 1/8	20	2 1/2
12	19	1 1/4	20 1/2	2	20 1/2	2 1/4	22	2 5/8
14	21	1 3/8	23	2 1/8	23	2 3/8	23 3/4	2 3/4
16	23 1/2	1 7/16	25 1/2	2 1/4	25 1/2	2 1/2	27	3
18	25	1 9/16	28	2 3/8	28	2 5/8	29 1/4	3 1/4
20	27 1/2	1 11/16	30 1/2	2 1/2	30 1/2	2 3/4	32	3 1/2
22	29 1/2	1 13/16	33	2 5/8	33	2 7/8	34 1/4	3 3/4
24	32	1 7/8	36	2 3/4	36	3	37	4
26	34 1/4	2	38 1/4	3 1/8	38 1/4	3 1/2	40	4 1/4
30	38 3/4	2 1/8	43	3 5/8	43	4	44 1/2	4 1/2
34	43 3/4	2 5/16	47 1/2	4	47 1/2	4 3/8	49	4 3/4
36	46	2 3/8	50	4 1/8	50	4 1/2	51 3/4	4 7/8
42	53	2 5/8	57	4 5/8	57	5 1/8	58 3/4	5 1/2

(1) The 1/16" raised face is included in "thickness 'Q'."
(2) The 1/4" raised face is not included in "thickness 'Q'."

BOLTING DIMENSIONS FOR 150 LB. FLANGES

NOM PIPE SIZE	150 LB. STEEL FLANGES Diam of Bolt Circle	Diam of Bolts	No. of Bolts	Length of Studs 1/16" Raised Face	Bolt Length
1/2	2 3/8	1/2	4	2 1/4	1 3/4
3/4	2 3/4	1/2	4	2 1/4	2
1	3 1/8	1/2	4	2 1/2	2
1 1/4	3 1/2	1/2	4	2 1/2	2 1/4
1 1/2	3 7/8	1/2	4	2 3/4	2 1/4
2	4 3/4	5/8	4	3	2 3/4
2 1/2	5 1/2	5/8	4	3 1/4	3
3	6	5/8	4	3 1/2	3
3 1/2	7	5/8	8	3 1/2	3
4	7 1/2	5/8	8	3 1/2	3
5	8 1/2	3/4	8	3 3/4	3 1/4
6	9 1/2	3/4	8	3 3/4	3 1/4
8	11 3/4	3/4	8	4	3 1/2
10	14 1/4	7/8	12	4 1/2	3 3/4
12	17	7/8	12	4 1/2	4
14	18 3/4	1	12	5	4 1/4
16	21 1/4	1	16	5 1/4	4 1/2
18	22 3/4	1 1/8	16	5 3/4	4 3/4
20	25	1 1/8	20	6	5 1/4
22	27 1/4	1 1/4	20	6 1/2	5 1/2
24	29 1/2	1 1/4	20	6 3/4	5 3/4
26	31 3/4	1 1/4	24	7	6
30	36	1 1/4	28	7 1/4	6 1/4
34	40 1/2	1 1/2	32	8	7
36	42 3/4	1 1/2	32	8 1/4	7
42	49 1/2	1 1/2	36	8 3/4	7 1/2

Stud lengths for lap joint flanges are equal to lengths shown plus the thickness of two laps of the stub ends.
Bolting arrangement for 125 lb. cast iron flanges are the same as shown for 150 lb. steel flanges.

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SFE-20 Tank Removal Level Lift

Job No	Sheet No 1	Rev
Part		
Ref		
By	Date 29-Oct-02	Chd
File sf20.std	Date/Time 30-Oct-2002 11:08	

Job Title

Client

Job Information

	Engineer	Checked	Approved
Name:			
Date:	29-Oct-02		

Structure Type	SPACE FRAME

Number of Nodes	1466	Highest Node	1546
Number of Plates	1604	Highest Plate	1794

Number of Basic Load Cases	1
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	

INEEL SFE-20 Tank Removal Level Lift

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Job Title		Job No	Sheet No 2	Rev
		Part		
		Ref		
		By	Date 29-Oct-02	Chd
Client		File sf20.std	Date/Time 30-Oct-2002 11:08	

Reaction Summary

	Node	L/C	Horizontal FX (kip)	Vertical FY (kip)	Horizontal FZ (kip)	Moment MX (kip*in)	MY (kip*in)	MZ (kip*in)
Max FX	1502	1:	**0.137**	0.487	-0.042	0.000	0.000	0.000
Min FX	1504	1:	**-0.137**	0.489	-0.036	0.000	0.000	0.000
Max FY	1504	1:	-0.137	**0.489**	-0.036	0.000	0.000	0.000
Min FY	1545	1:	0.040	**0.478**	0.086	0.000	0.000	0.000
Max FZ	1545	1:	0.040	0.478	**0.086**	0.000	0.000	0.000
Min FZ	1502	1:	0.137	0.487	**-0.042**	0.000	0.000	0.000
Max MX	1502	1:	0.137	0.487	-0.042	**0.000**	0.000	0.000
Min MX	1502	1:	0.137	0.487	-0.042	**0.000**	0.000	0.000
Max MY	1502	1:	0.137	0.487	-0.042	0.000	**0.000**	0.000
Min MY	1502	1:	0.137	0.487	-0.042	0.000	**0.000**	0.000
Max MZ	1502	1:	0.137	0.487	-0.042	0.000	0.000	**0.000**
Min MZ	1502	1:	0.137	0.487	-0.042	0.000	0.000	**0.000**

Reactions

Node	L/C	Horizontal FX (kip)	Vertical FY (kip)	Horizontal FZ (kip)	Moment MX (kip*in)	MY (kip*in)	MZ (kip*in)
1502	1:	0.137	0.487	-0.042	0.000	0.000	0.000
1504	1:	-0.137	0.489	-0.036	0.000	0.000	0.000
1543	1:	-0.040	0.488	-0.007	0.000	0.000	0.000
1545	1:	0.040	0.478	0.086	0.000	0.000	0.000

INEEL SFE-20 Tank Removal Level Lift

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Job No	Sheet No 3	Rev
Part		
Ref		
By	Date 29-Oct-02	Chd
File sf20.std	Date/Time 30-Oct-2002 11:0	

Job Title

Client

Plate Centre Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (ksi)	Qy (ksi)	Fx (ksi)	Fy (ksi)	Fxy (ksi)	Mx (kip'in/in)	My (kip'in/in)	Mxy (kip'in/in)
Max Qx	1772	1:	**-0.756**	0.064	0.241	0.705	-0.085	-0.096	-0.032	0.020
Max Qy	1658	1:	0.176	**-2.358**	0.477	1.099	0.490	-0.056	-0.078	0.039
Max Fx	1637	1:	-0.023	-0.386	**3.352**	2.153	-0.079	0.026	0.091	-0.003
Max Fy	1627	1:	0.156	0.751	2.744	**2.613**	-0.525	0.066	0.055	0.028
Max Fxy	1594	1:	-0.006	0.025	0.469	0.664	**-0.706**	-0.013	-0.007	-0.011
Max Mx	1772	1:	-0.756	0.064	0.241	0.705	-0.085	**-0.096**	-0.032	0.020
Max My	1655	1:	0.034	-2.220	0.994	0.590	0.492	0.033	**0.112**	-0.014
Max Mxy	1659	1:	-0.193	2.225	0.806	1.275	0.531	0.055	0.071	**-0.041**

Plate Centre Principal Stress Summary

			Principal		Von Mis	
	Plate	L/C	Top (ksi)	Bottom (ksi)	Top (ksi)	Bottom (ksi)
Max (t)	1655	1:	**11.479**	10.607	10.089	9.860
Max (b)	1638	1:	7.945	**11.452**	6.886	9.988
Max VM (t)	1655	1:	11.479	10.607	**10.089**	9.860
Max VM (b)	1638	1:	7.945	11.452	6.886	**9.988**

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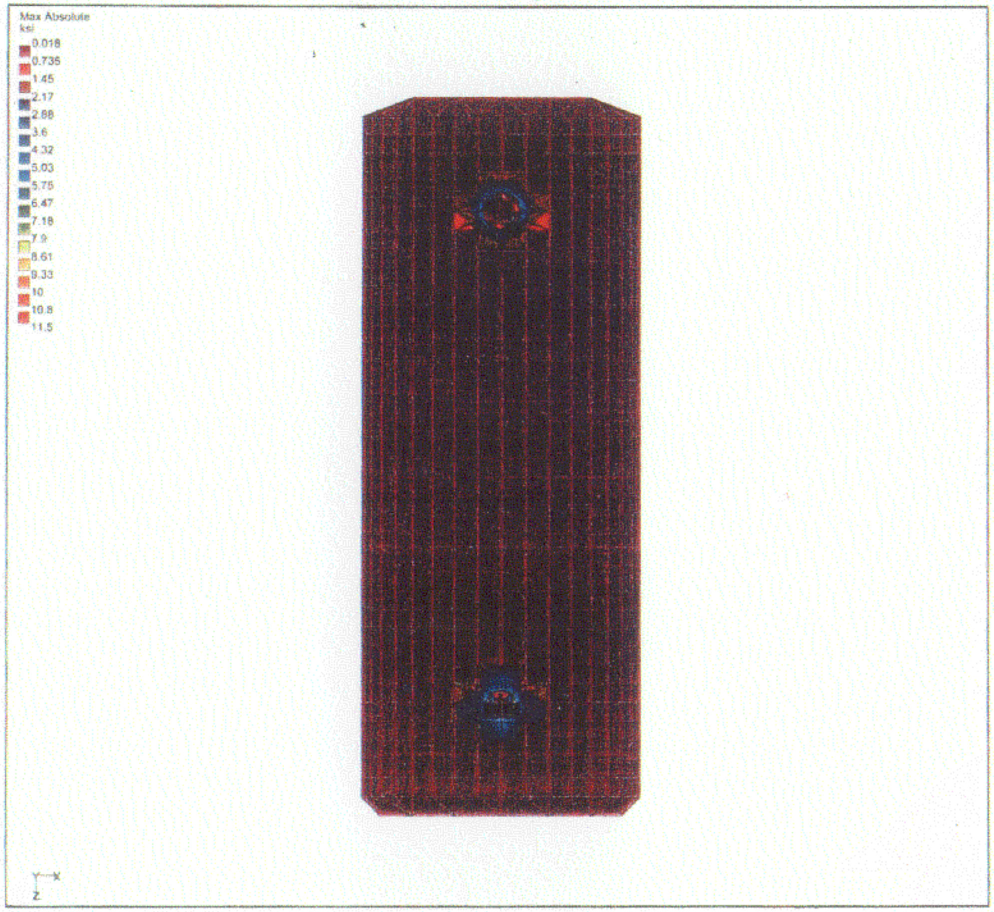
SFE-20 Tank Removal Level Lift	Job No	Sheet No 4		Rev
	Part			
Job Title	Ref			
	By	Date 29-Oct-02		Chd
Client	File sf20.std	Date/Time 30-Oct-2002 11:08		



Plan View

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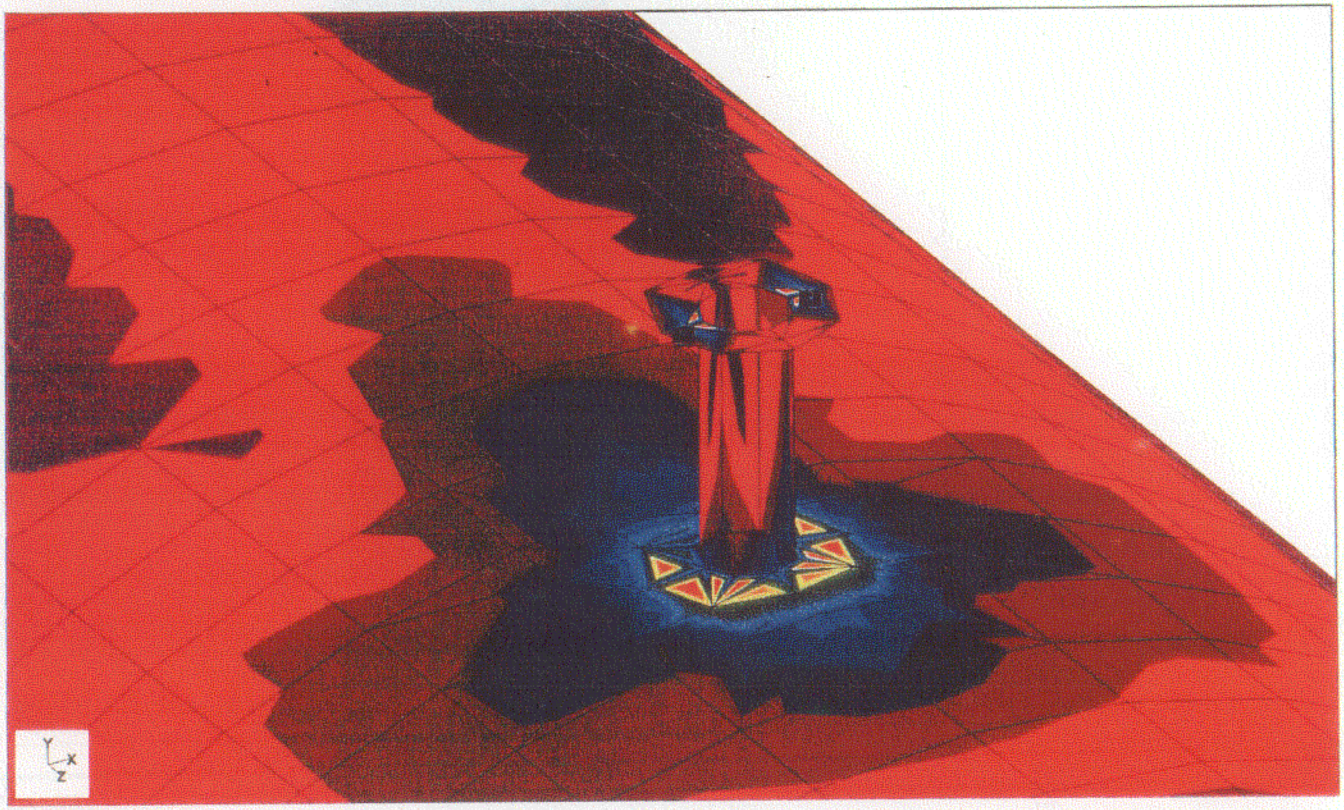
SFE-20 Tank Removal Level Lift	Job No	Sheet No 5	Rev
	Part		
Job Title	Ref		
	By	Date 29-Oct-02	Chd
Client	File sf20.std	Date/Time 30-Oct-2002 11:08	



Flange Detail

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SFE-20 Tank Removal Angle Lift

Job No	Sheet No 1	Rev
Part		
Ref		
By	Date 29-Oct-02	Chd
File sfangle2.std	Date/Time 05-Nov-2002 16:07	

Job Title

Client

Job Information

	Engineer	Checked	Approved
Name:			
Date:	29-Oct-02		

Structure Type	SPACE FRAME

Number of Nodes	1565	Highest Node	1647
Number of Plates	1761	Highest Plate	2011

Number of Basic Load Cases	1
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	

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SFE-20 Tank Removal Angle Lift	Job No	Sheet No 2	Rev
Job Title	Part		
	Ref		
	By	Date 29-Oct-02	Chd
Client	File sfangle2.std	Date/Time 05-Nov-2002 16:07	

Reactions

		Horizontal	Vertical	Horizontal	Moment		
Node	L/C	FX (kip)	FY (kip)	FZ (kip)	MX (kip*in)	MY (kip*in)	MZ (kip*in)
1636	1:	0.004	-0.166	-1.220	0.000	0.000	0.000
1647	1:	-0.004	1.455	-0.316	0.000	0.000	0.000

Plate Centre Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (ksi)	Qy (ksi)	Fx (ksi)	Fy (ksi)	Fxy (ksi)	Mx (kip*in/in)	My (kip*in/in)	Mxy (kip*in/in)
Max Qx	1924	1:	**0.503**	0.187	-0.192	-0.596	-0.234	-0.016	-0.057	0.048
Max Qy	1927	1:	-0.022	**1.030**	-0.252	-0.579	0.321	0.083	-0.029	0.007
Max Fx	1820	1:	0.062	-0.384	**2.996**	2.448	0.179	0.046	0.019	-0.006
Max Fy	1834	1:	0.132	0.123	2.318	**3.009**	0.035	-0.019	-0.053	-0.001
Max Fxy	1973	1:	-0.000	-0.015	-0.325	-0.579	**-1.030**	-0.000	-0.002	-0.001
Max Mx	1922	1:	-0.334	1.001	-1.248	-0.684	-0.019	**-0.216**	-0.086	0.036
Max My	1930	1:	-0.321	-0.199	-0.907	-0.996	-0.066	0.208	**0.171**	0.026
Max Mxy	1923	1:	-0.157	-0.068	-0.590	-0.479	-0.249	0.085	0.082	**-0.054**

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SFE-20 Tank Removal Angle Lift

Job No	Sheet No 3	Rev
Part		
Ref		
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Job Title

Client

Plate Centre Principal Stress Summary

	Plate	L/C	Principal		Von Mis	
			Top (ksi)	Bottom (ksi)	Top (ksi)	Bottom (ksi)
Max (t)	1624	1:	**7.541**	4.634	6.877	4.023
Max (b)	1834	1:	2.098	**8.118**	2.414	7.031
Max VM (t)	1624	1:	7.541	4.634	**6.877**	4.023
Max VM (b)	1834	1:	2.098	8.118	2.414	**7.031**

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SFE-20 Tank Removal Angle Lift	Job No	Sheet No 4		Rev
	Part			
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Max Stress

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SFE-20 Tank Removal Angle Lift

Job Title	Job No	Sheet No 5	Rev
	Part		
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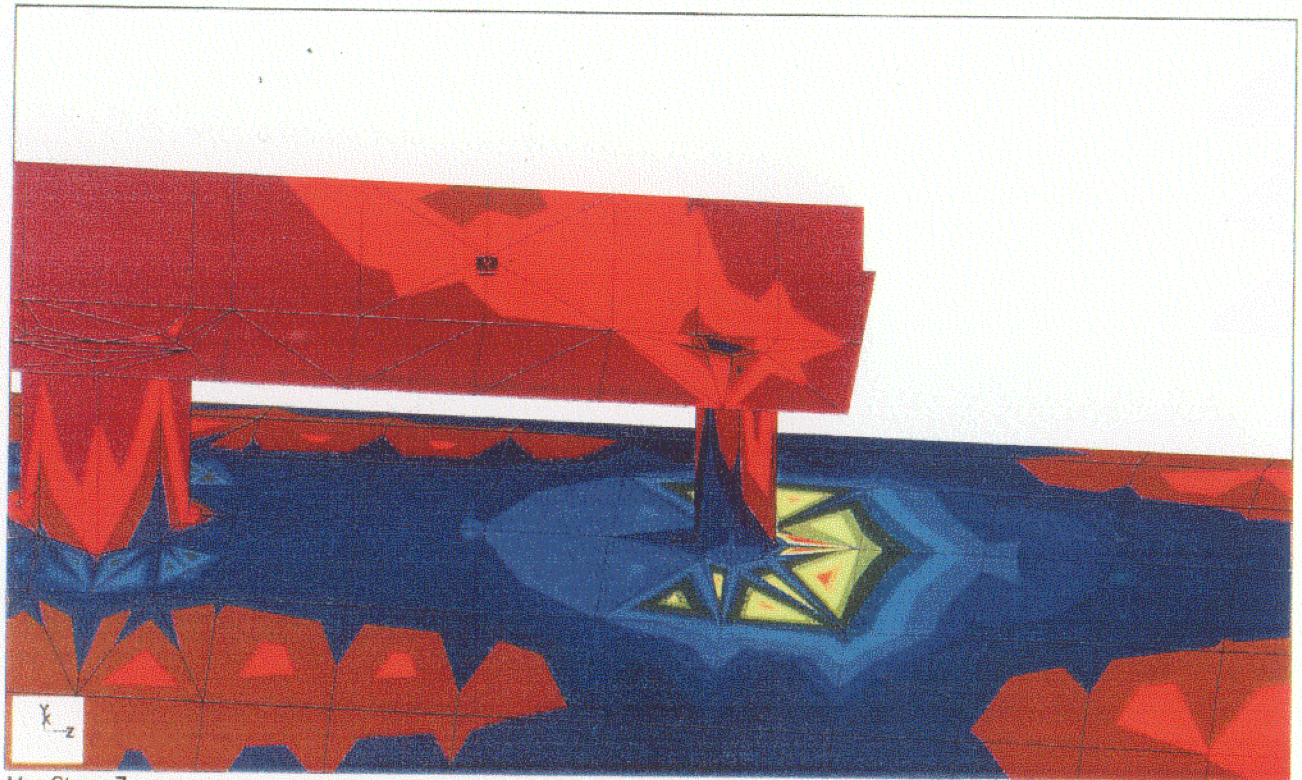
Client	By	Date 29-Oct-02	Chd
	File sfangle2.std	Date/Time 05-Nov-2002 16:07	



Max Stress Zoom

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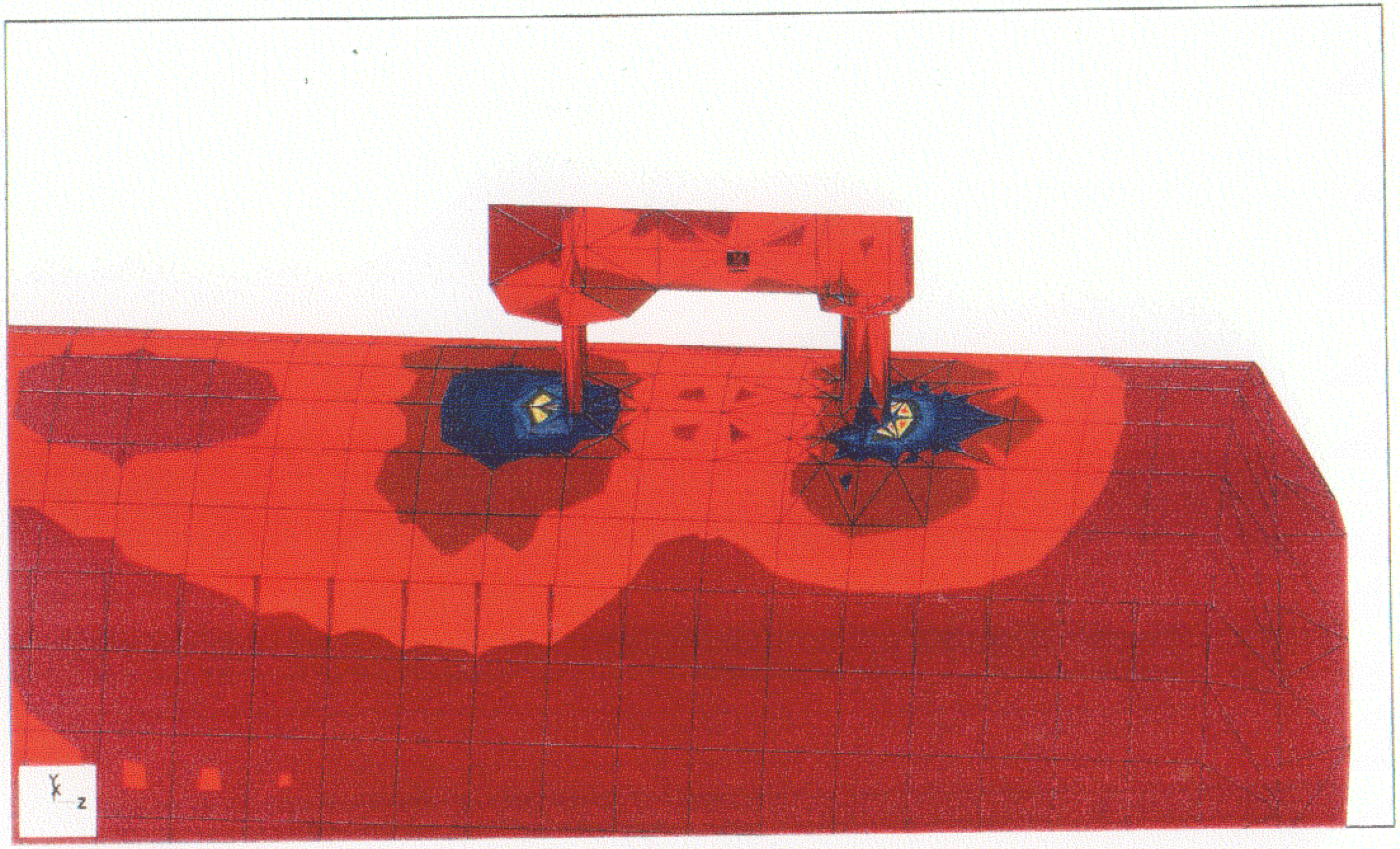
Job Title: SFE-20 Tank Removal Angle Lift	Job No	Sheet No 6	Rev
	Part		
	Ref		
	By	Date 29-Oct-02	Chd
Client	File sfangle2.std	Date/Time 05-Nov-2002 16:07	



Stress Zoom

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SFE-20 Tank Removal Angle Lift

Job Title		Job No	Sheet No 1	Rev
		Part		
		Ref		
		By	Date 29-Oct-02	Chd
Client		File sfangle.std	Date/Time 31-Oct-2002 10:24	

Job Information

	Engineer	Checked	Approved
Name:			
Date:	29-Oct-02		

Structure Type	SPACE FRAME

Number of Nodes	1466	Highest Node	1546
Number of Plates	1604	Highest Plate	1794

Number of Basic Load Cases	1
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	

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SFE-20 Tank Removal Angle Lift

Job No	Sheet No 2	Rev
Part		
Ref		
By	Date 29-Oct-02	Chd
File sfangle.std	Date/Time 31-Oct-2002 10:24	

Job Title

Client

Plate Centre Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (ksi)	Qy (ksi)	Fx (ksi)	Fy (ksi)	Fxy (ksi)	Mx (kip-in/in)	My (kip-in/in)	Mxy (kip-in/in)
Max Qx	1772	1:	**-1.260**	0.096	0.291	0.251	-1.380	-0.167	-0.065	0.033
Max Qy	1790	1:	-0.020	**3.199**	1.319	0.647	1.254	-0.040	-0.132	-0.049
Max Fx	1705	1:	0.025	-0.729	**7.088**	3.009	0.147	0.054	0.166	-0.015
Max Fy	1710	1:	0.614	0.948	3.421	**4.376**	0.377	-0.129	-0.125	-0.036
Max Fxy	1713	1:	-0.305	-0.023	3.547	2.023	**1.907**	0.055	0.026	-0.024
Max Mx	1772	1:	-1.260	0.096	0.291	0.251	-1.380	**-0.167**	-0.065	0.033
Max My	1705	1:	0.025	-0.729	7.088	3.009	0.147	0.054	**0.166**	-0.015
Max Mxy	1790	1:	-0.020	3.199	1.319	0.647	1.254	-0.040	-0.132	**-0.049**

Plate Centre Principal Stress Summary

	Plate	L/C	Principal		Von Mis	
			Top (ksi)	Bottom (ksi)	Top (ksi)	Bottom (ksi)
Max (t)	1705	1:	**19.183**	13.082	16.795	14.212
Max (b)	1710	1:	11.373	**19.865**	9.864	17.360
Max VM (t)	1705	1:	19.183	13.082	**16.795**	14.212
Max VM (b)	1710	1:	11.373	19.865	9.864	**17.360**

INEEL SFE-20 Tank Removal Angle Lift

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Job Title	Job No	Sheet No 3	Rev
	Part		
	Ref		
	By	Date 29-Oct-02	Chd
Client	File sfangle.std	Date/Time 31-Oct-2002 10:24	

Reactions

Node	L/C	Horizontal FX (kip)	Vertical FY (kip)	Horizontal FZ (kip)	Moment MX (kip*in)	Moment MY (kip*in)	Moment MZ (kip*in)
1502	1:	0.036	0.330	-0.097	0.000	0.000	0.000
1504	1:	0.001	-0.284	-0.352	0.000	0.000	0.000
1543	1:	0.287	0.862	-0.925	0.000	0.000	0.000
1545	1:	-0.324	0.340	-0.113	0.000	0.000	0.000

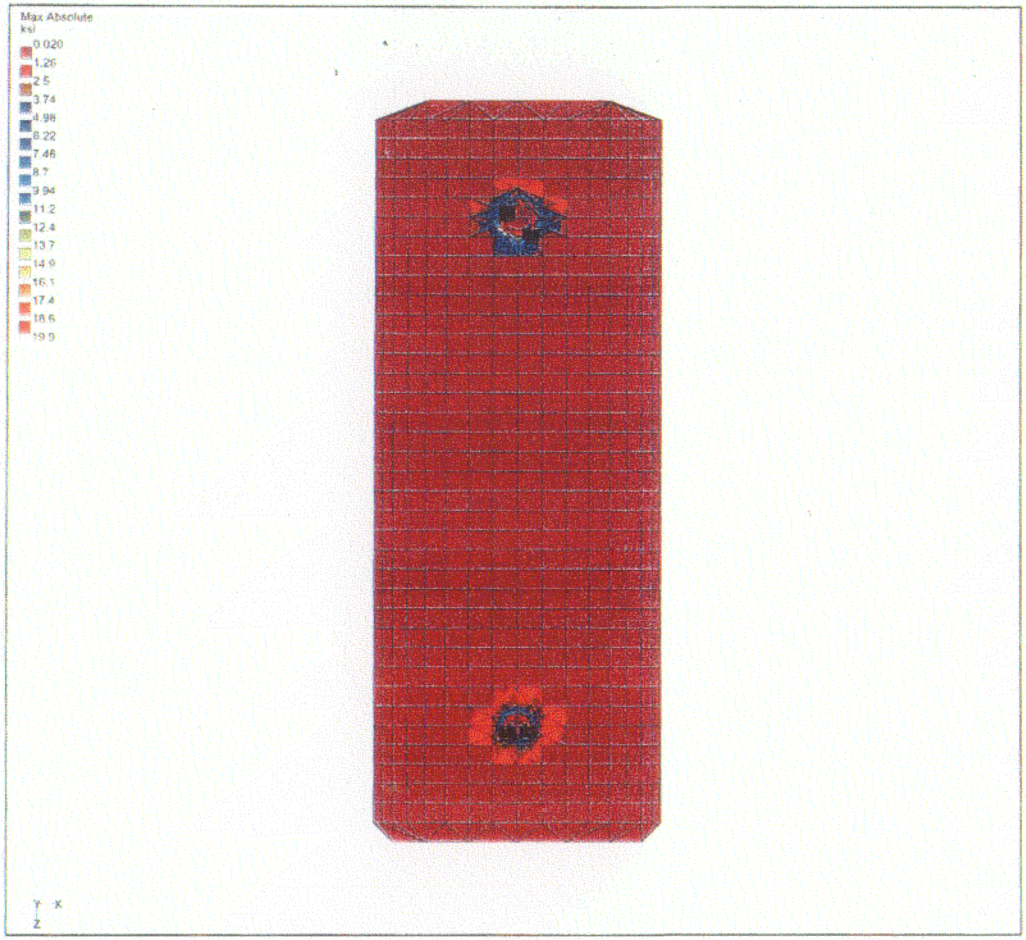
Reaction Summary

	Node	L/C	Horizontal FX (kip)	Vertical FY (kip)	Horizontal FZ (kip)	Moment MX (kip*in)	Moment MY (kip*in)	Moment MZ (kip*in)
Max FX	1543	1:	**0.287**	0.862	-0.925	0.000	0.000	0.000
Min FX	1545	1:	**-0.324**	0.340	-0.113	0.000	0.000	0.000
Max FY	1543	1:	0.287	**0.862**	-0.925	0.000	0.000	0.000
Min FY	1504	1:	0.001	**-0.284**	-0.352	0.000	0.000	0.000
Max FZ	1502	1:	0.036	0.330	**-0.097**	0.000	0.000	0.000
Min FZ	1543	1:	0.287	0.862	**-0.925**	0.000	0.000	0.000
Max MX	1502	1:	0.036	0.330	-0.097	**0.000**	0.000	0.000
Min MX	1502	1:	0.036	0.330	-0.097	**0.000**	0.000	0.000
Max MY	1502	1:	0.036	0.330	-0.097	0.000	**0.000**	0.000
Min MY	1502	1:	0.036	0.330	-0.097	0.000	**0.000**	0.000
Max MZ	1502	1:	0.036	0.330	-0.097	0.000	0.000	**0.000**
Min MZ	1502	1:	0.036	0.330	-0.097	0.000	0.000	**0.000**

ENGINEERING DESIGN FILE

INEEL SFE-20 Tank Removal Angle Lift

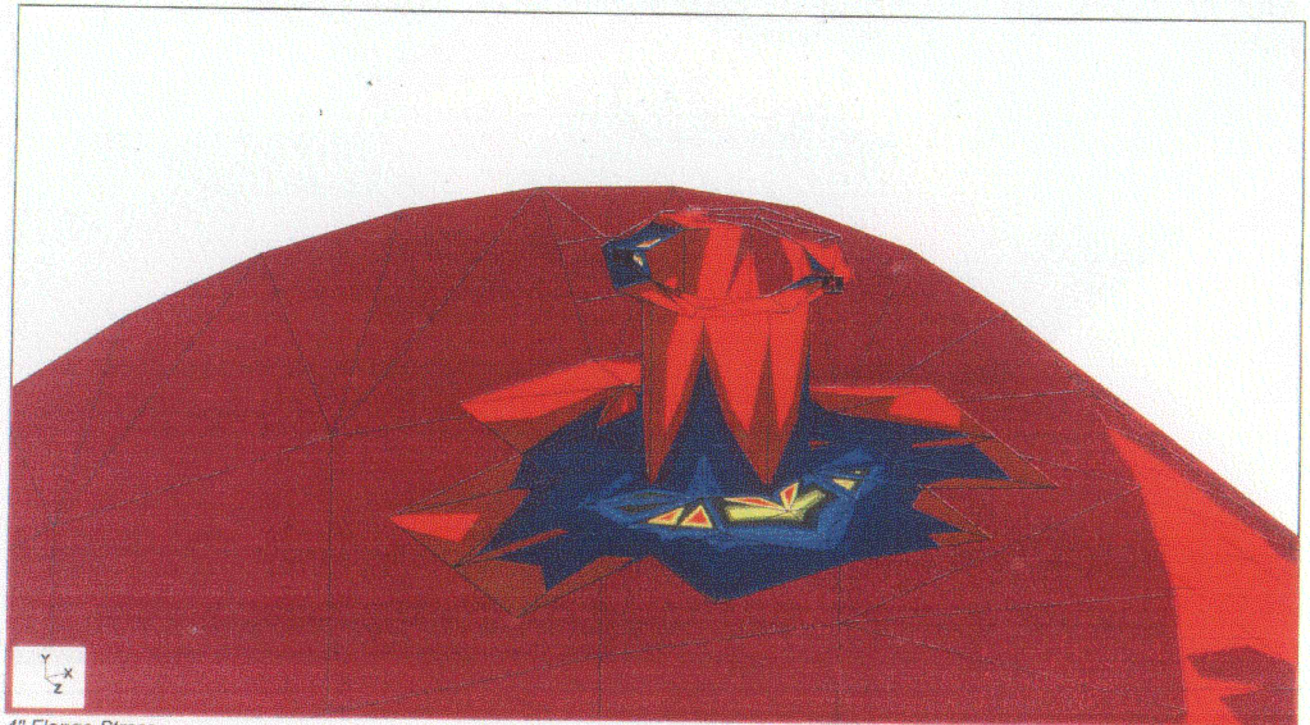
Job Title	Job No	Sheet No 4		Rev
	Part			
	Ref			
	By	Date 29-Oct-02	Chd	
Client	File sfangle.std	Date/Time 31-Oct-2002 10:24		



Stress Plan View

ENGINEERING DESIGN FILE

SFE-20 Tank Removal Angle Lift	Job No	Sheet No 5	Rev
Job Title	Part		
	Ref		
Client	By	Date 29-Oct-02	Chd
	File sfangle.std	Date/Time 31-Oct-2002 10:24	



4" Flange Stress

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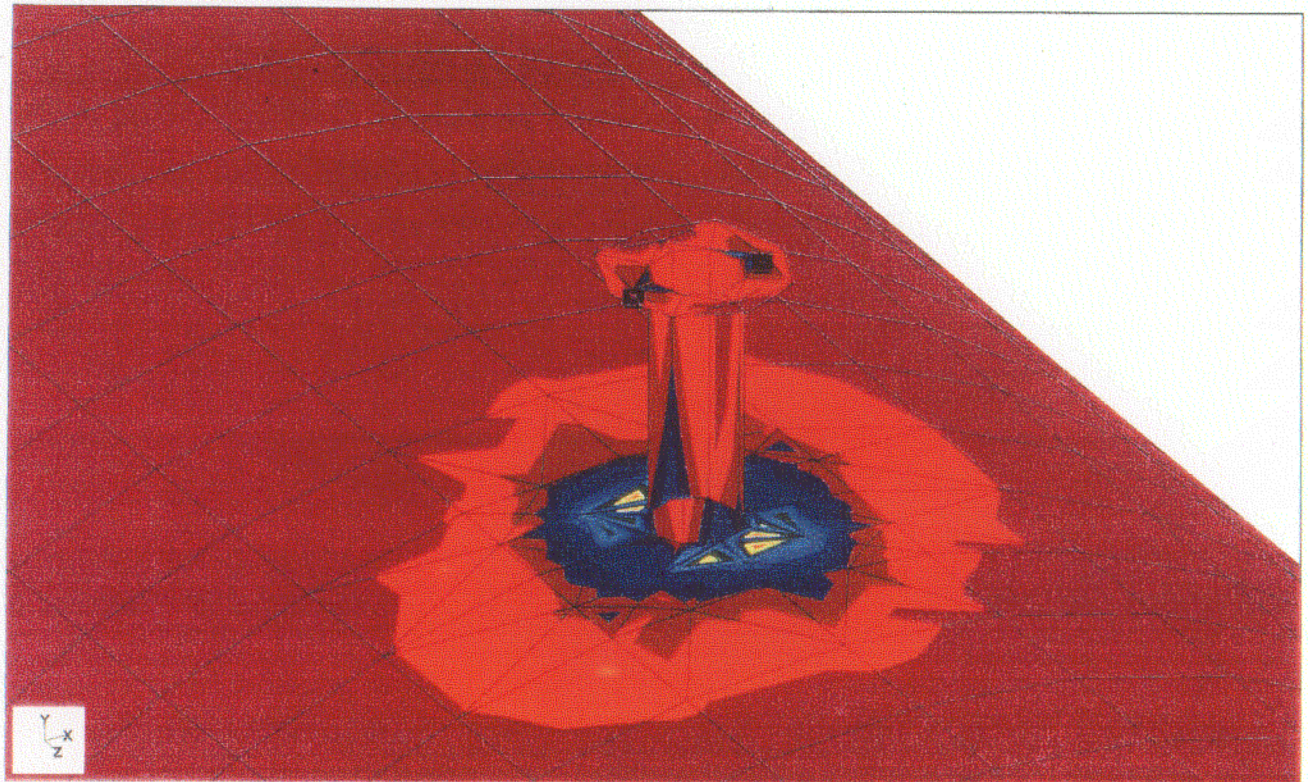
SFE-20 Tank Removal Angle Lift

Job No	Sheet No 6		Rev
Part			
Ref			
By	Date 29-Oct-02	Chd	
File sfangle.std	Date/Time 31-Oct-2002 10:24		

Job Title

Client



2" Flange Stress